1984

A preliminary analysis of C-12 aircraft usage by the Navy Air Logistics System.

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http://hdl.handle.net/10945/19503

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

A PRELIMINARY ANALYSIS OF C-12 AIRCRAFT
USAGE BY THE NAVY AIR LOGISTICS SYSTEM

by

Robert Louis Gilson

September 1984

Thesis Advisor: Alan W. McMasters

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A PRELIMINARY ANALYSIS OF C-12 AIRCRAFT USAGE BY THE NAVYAIR LOGISTICS SYSTEM		5. TYPE OF REPORT & PERIOD COVERED MASTER'S THESIS SEPTEMBER 1984
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Robert Louis Gilson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943		12. REPORT DATE SEPTEMBER 1984
		13. NUMBER OF PAGES 99
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Navy Air Logistics. Passenger Transportation, Navy, New Aircraft, basing of.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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S/N 0102-LF-014-6601

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A Preliminary Analysis of C-12 Aircraft Usage by the Navy Air Logistics System

by

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MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
September 1984

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TABLE OF CONTENTS

LIST OF FIGURES

ACKNOWLEDGMENT

The author of this thesis wishes to express his gratitude to the officers, men, and employees of the Navy Air Logistics Office and the Navy Air Logistics Control Office, Eastern Pacific, for their time, their patience, and their cooperation.

I. INTRODUCTION

All students of military history learn quickly that logistics organization is crucial to any successful military operation. The invasion of Granada in the summer of 1983 graphically illustrated the advantage of being able to move troops, equipment and supplies quickly and efficiently. Yet, the cost of this support capability has been a hotly debated issue, particularly since the United States left Vietnam. In 1972, the Brookings Institute published a report stating that support costs had grown to fully one-third of the total defense budget. [Ref. 1]

Perhaps no military service is more sensitive to the issue of logistic support than the United States Navy. The limited storage capacity of ships, combined with the isolation from shore-based logistic resupply points when on the high seas, places a premium on effective logistics support. Admiral Thomas Moorer, in testimony before the House Armed Services Committee in October, 1977, stated the view of many combat commanders regarding logistics support.

> "We're not interested in the cost per ton mile. We might take a C-9 (aircraft) and fly five pounds to Rota (Spain) so a $300 million sub can get underway. How things work today is meaningless, what matters is how it's going to work during a war. The key question is: How do you best maintain fleet readiness at sea?"

While that view is completely understandable during wartime, and certainly not without historical precedent, it is difficult to defend in its entirety in today's atmosphere of high prices and constrained budgets. Logistics planners are becoming increasingly aware that while wartime effectiveness is crucial, peacetime efficiency is also vital. If credibility is to be maintained, the Congress and the public must become convinced that logistic support costs are being adequately controlled.

Obviously, the term Logistic Support encompasses a wide variety of issues, costs, and commands within any given service. One area that has been subjected to intense and continuing criticism is the Navy Air Logistics organization. Since 1975, Comptroller General Reports and Naval Audit Service Reports have criticized the system and the individual commands within the the system for inefficient use of assigned aircraft assets.

During the summer of 1983, the Naval Air Logistics Control Office, Eastern Pacific (NALCOEP), one of subordinate scheduling commands within the air logistics organization, requested assistance from the Naval Postgraduate School in examining their utilization of assigned aircraft. Since many NALCOEP decisions are influenced by system-wide policies and regulations, any analysis must necessarily begin with an understanding of NALCOEP's place in the Navy Air Logistics system.

A. NAVY AIR LOGISTICS SYSTEM OVERVIEW

The basis for a Navy organic airlift capability resides in the United States Code [Ref. 2], and the Navy Air Logistics System is a direct result of this authority. However, specific justification for this capability, and methodology for determining its effectiveness, has never been fully developed. The system is controlled by Department of Defense and Chief of Naval Operations (CNO) policies. The Chief of Naval Reserve has been designated as CNO Executive Agent for Department of the Navy (DON) Organic Airlift [Ref. 3]. The Navy Air Logistics Office (NALO) has been established as a member of the staff of the Chief of Naval Reserves specifically to perform this function. In addition to scheduling some of the aircraft assets assigned to the system, the mission statement of this office charges it with:

- the development of organic airlift management policy for the Navy;

- the operation of an aircraft data collection and information system;

- the coordination of schedules of Navy organic airlift aircraft within CONUS;

- the implementation of advanced aircraft scheduling techniques at Navy and Marine Corps airlift scheduling activities;

- the analysis of data to aid airlift asset management and justification.

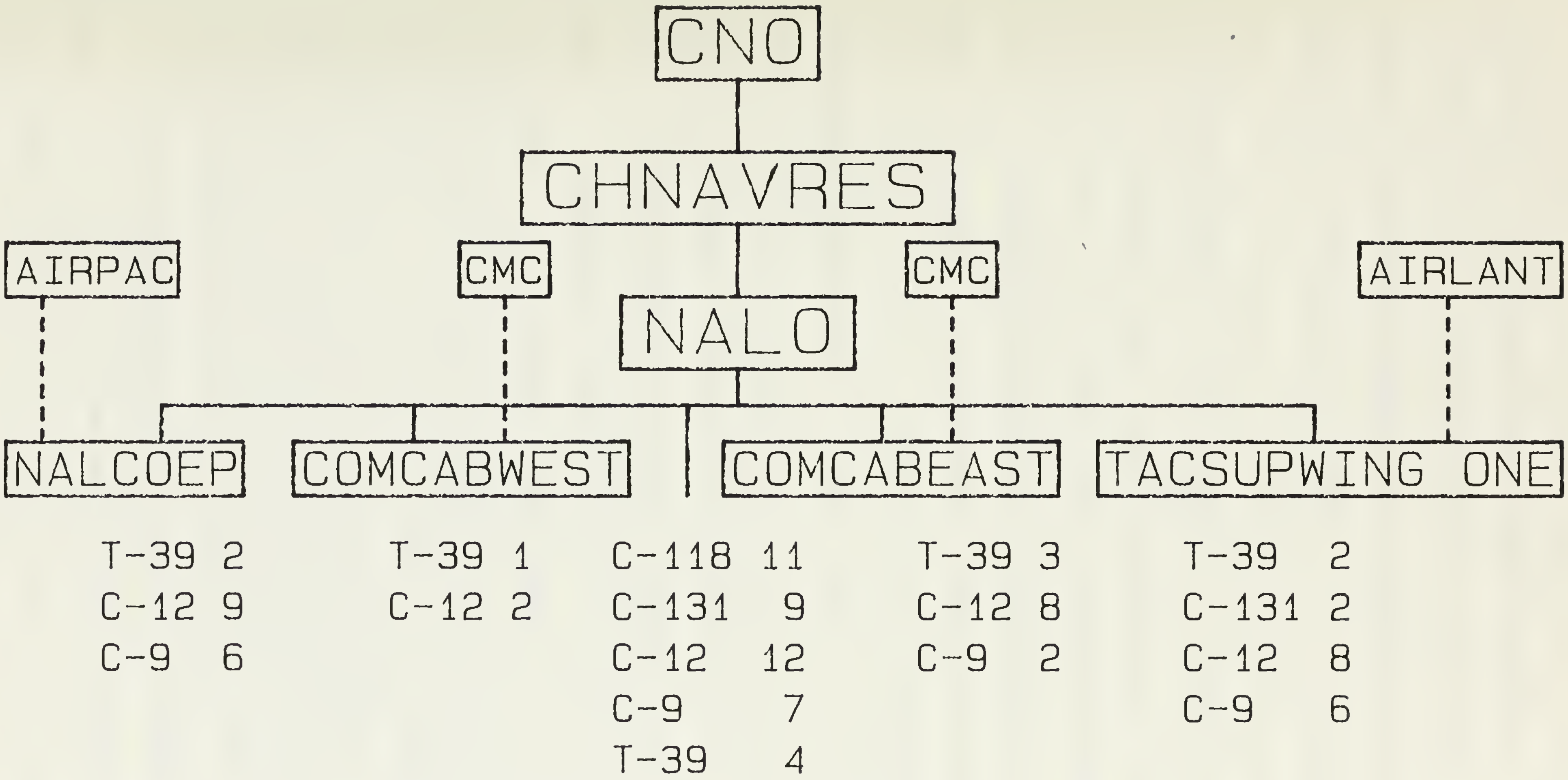


Figure 1 - Air Logistics System Organization Chart

1. Organization

The overall organization of the Navy's Air Logistics System within the continental United States is reflected in Figure 1. The type and number of aircraft scheduled by each command is listed below each scheduler. Four items are worth noting.

First, while NALO is charged with the development of policy, it is subject to the guidance and requirements of the Chief of Naval Reserve and the CNO. Obviously, Secretary of Defense policy must also be observed.

Second, each regional scheduler is responsible to two distinct commands. Obviously, each command is responsible to NALO for adhering to system policies and procedures. Additionally, each scheduler is also responsible to Commander, Naval Air Forces, U. S. Pacific Fleet; Commander, Naval Air Forces, U. S. Atlantic Fleet, or Commandant, Marine Corps; for operational support. This can create a conflict for schedulers as they try to meet the policies levied by NALO while simultaneously attempting to meet the requirements of their respective operational commanders. This is particularly true when the operational commander desires transportation for only one or two personnel. While such a flight may not be economically feasible for the system, funds are often not made available for alternative transportation arrangements.

Third, though each scheduler controls the aircraft, the Station Commanding Officer owns the aircraft and is responsible for providing crews from station personnel. No billets exist to support the aircraft and all missions are assigned as "Additional Duty." This became quite evident during the analysis of the data and will be discussed again at that point.

Fourth, the aircraft assignments shown were current at the end of Fiscal Year 83 and do not accurately represent the assignment of assets at the beginning of that Fiscal Year. Several aircraft had been reassigned in December 1982. This will be touched upon again briefly in Chapter IV.

2. Policy

The primary policy guidance followed throughout the system is most succinctly stated in letter to Commander in Chief, United States Pacific Fleet. Although the letter is several years old, the basic policy has not changed.

> "Among the actions necessary are the absolute adherance to both the spirit and the letter of DON and OPNAV directives regarding use of our organic airlift aircraft. In general, this means that Navy organic aircraft will be used to meet requirements which are justified by wartime training requirements, urgency, security, or military effectiveness and then only when the lift is outside the recognized mission of commercial carriers or the Military Airlift Command. In every case, the lift chosen must be the lowest cost mode that will adequately meet the requirement." [Ref. 4]

This guidance has been implemented in practice by specifying that assets employed in air logistic support shall not be utilized for predictable passenger movements and routine supply or resupply operations which can be performed by MAC (Military Airlift Command) or commercial contract air service. [Ref. 5] Specific purposes for flights have been spelled out in several official instructions [Ref. 6], [Ref. 7]; however, these purposes can be summarized in three key phrases [Ref. 8]:

- Short-fuzed - unscheduled, short-notice requirements;
- Low Volume - requirements which cannot be predicted to occur with regularity due to their infrequent nature;
- High Priority - requirements necessitating immediate action on the part of the logistics organization.

B. PROBLEM IDENTIFICATION

It quickly became obvious to the author that the initial problem, examining the utilization of assigned aircraft, was significantly larger and more complex than could be handled within the available time and resources. Referring again to Figure 1, it can be seen that over 100 aircraft could be involved in the analysis. Discussions with the database custodian, NALO, indicated that such an analysis would involve well in excess of 300,000 individual records (See Chapter 2). Finally, no measures of efficiency within the system have been identified, therefore some measure of the relative efficiency of each base when compared to all other bases needed to be developed.

The only practical method of limiting the scope of the investigation was to restrict the analysis to one type of aircraft. The T-39 Sabreliner, a seven passenger jet aircraft, is primarily a Flag Officer support aircraft. Only 14 exist in the system, therefore it was eliminated. Of the two remaining aircraft controlled by NALCOEP, the UC-12 and the DC-9, the C-12 appeared to offer the most local, autonomous control and had the least well defined mission. The 39 aircraft throughout the NALO system constituted the largest single aircraft type and it was decided to use the C-12 aircraft in this initial analysis.

The question of efficient utilization still encompassed a large number of variables, even after restricting consideration to one type of aircraft. Among the questions being asked by NALCOEP were:

- What type of basing should be used? Station aircraft as is currently being done, or creation of C-12 aircraft squadrons?
- In either case, where should the aircraft be home-based?
- What measure of efficiency was appropriate to the command mission?
- What type of maintenance program should be used? Civilian contract as is currently being done, or should Navy personnel be used?
- Could more customer requests be met by a different scheduling technique? What kind?

Additional discussions led to the decision to place more restrictions on the initial area of analysis. One of NALCOEP's concerns regarding the C-12 aircraft was that it was in a five-year procurement plan and more aircraft were due to be delivered over the next two to three years. The most immediate benefits could be derived from determining the best locations for some of these new aircraft.

C. THESIS PURPOSE

This thesis will attempt to determine the best location for new C-12 aircraft. It begins with analyses of current locations and their operations. It then attempts to evaluate the relative efficiency of these bases in using the C-12. It will then attempt to determine if any of the available data might indicate possible future optimum assignments.

D. CHAPTER PREVIEW

Chapter II will discuss the data available for analysis and how the system obtains this data. It will also discuss the problems discovered in the data and explain the reasons for distilling the data prior to analysis.

Chapter III describes the initial analysis performed on the data. It presents several graphical views of the data, describes potential variables of interest and the reasoning used to isolate the significant variables.

Chapter IV contains a more detailed analysis. It includes the interpretation of several of the graphs, explanations for several of the outliers observed in Chapter III, and suggests measures of performance for evaluating aircraft usage.

Chapter V presents the conclusions of the analyses and recommendations for action. It also suggests several additional areas for further study and analysis.

II. DATA

Prior to any analysis, a description of the nature of the available data should be provided. No valid interpretations can be drawn without knowing the source of the data. It would be impossible to draw inferences or identify anomolies without a knowledge of the structure of the data and how the data is affected by the aircraft under consideration. This chapter will therefore attempt to consider such issues. It begins with a brief description of the C-12 aircraft and is followed by a description of the data and how it is obtained. The structure of the database will then be reviewed. Finally. the rationale for the specific data selected for this thesis is presented.

A. THE UC-12B AIRCRAFT

The UC-12B aircraft is a twin-engine turbo-prop aircraft manufactured by the Beech Aircraft Company. Its commercial equivalent is a Beech Super King Air Model 200. In its standard configuration it can carry seven passengers and approximately 400 pounds of baggage or cargo. The seats can be removed, allowing for a full cargo load of approximately 2,000 pounds. This configuration is seldom used, however, due to the difficulty in removing the seats and the lack of onboard cargo-handling equipment. The aircraft is typically used for short, commuter-type flights between air stations and is seldom used on cross-country flights. It requires a fuel stop every 800 to 1,200 miles depending on passenger and/or cargo load. With an average speed of 200 miles per hour, the aircraft is limited to a range of 1,200 miles without an overnight rest stop for the crew, which consists of a pilot, a co-pilot, and an aircrewman.

B. DATA SOURCES

The data which will be described in the next section is derived primarily from three sources: the customers, the schedulers, and the aircrews. This section will describe the process of requesting, scheduling, and reporting a flight. These procedures are spelled out in depth in OPNAVINST 4631.2B [Ref. 2]. Emphasis will be placed on the relationship between each action and the data collected.

1. Requesting a Flight

In general, customers desiring a flight send a message to the appropriate scheduling command in Figure 1, Chapter I. The message is formatted according to the OPNAV Instruction cited above, and several different flights may be requested in the same message. A copy of a typical message is shown in Figure A.1 of Appendix A. This message is the primary source of data in the Flight Request File, to be discussed in Section C.1 below. The information enters the computerized database by a method known as "Message

Cracking" - a computerized algorithm wherein the computer itself deciphers the message and appends the information to the database.

In addition to the Flight Request Message, NALO maintains a "Walk-Up Window" which is manned by the staff and equipped with a computer terminal. Requests at this window are manually entered on the terminal using the same format as the message.

Telephone inquiries as to flight availability are an everyday occurrence at all scheduling commands and there does not appear to be a standardized method of handling these inquiries, at least in practice. Theoretically, all requests for flights must eventually be submitted by message or via the NALO walkup window. However, in many cases when requests received by telephone can not be accommodated, the required official message request is never released by the customer. This results in a loss of demand data to the system. It is estimated by NALCOEP and NALO staff that as much as 80 percent of such "flight regret" information is never recorded as a system demand.

2. <u>Scheduling a Flight</u>

The Flight Advisory Message is the primary means of communication between the schedulers, the customers and aircrews. It consists of a message to the requesting customer and other appropriate commands that the request has been accepted, passed to another scheduling command, or that their request can not be accommodated and the reason for the rejection of the request. The latter message is called a regret message because of its opening phrase "REGRET UNABLE... ."

The most common type of Flight Advisory Message is that which schedules a flight. An example of this type of message is shown in Figure A.2 of Appendix A. Although this particular example schedules a flight for a C-9 aircraft, the format is the same for all types of aircraft. From the information in the Flight Requests, the scheduler puts together a flight itinerary. Each flight consists of from one to perhaps ten or more "lifts" or "legs." Although there are some minor differences between the two terms, for the purpose of this thesis "lifts" and "legs" can be considered interchangable and apply to that segment of a flight which starts with one takeoff and ends with the next consecutive landing. Chapter III will examine the distribution of the number of legs per flight.

As can be seen from the Figure A.2, each message consists of two parts. Paragraph one is the general schedule of the flight and includes how many passenger seats are still available, or how much cargo space is still available, on the given leg. This information is generated from the Flight Advisory File to be discussed in section C.2.

Paragraphtwo consists of the details of each leg of the flight and includes how many seats and how much cargo is scheduled, the command receiving the transportation, and the local flight coordinator. The Flight Lift File, to be discussed in Section C.3, generates this section of the message. The information for this message is entered manually by the scheduler (or a clerk/assistant) and becomes a part of the database. 72 to 96 hours before the scheduled departure, the computer generates the message for release. This message is transmitted to other scheduling commands, to bases where the aircraft will stop, and to commands which have passengers scheduled on the flight. These commands, and other commands with access to the message files of the receiving commands, have the opportunity to request any of the available seats.

3. Reporting a Flight

At the conclusion of the flight, the pilot files a Logistics Flight Report, shown in Appendix B. This information is also entered into the computer and appended to the Logistics Flight Report File to be discussed in Section C.4, subsequently linking the original Flight Requests to the Flight Advisory messages through three keyed fields. It provides information on the number of passengers and cargo flown (both scheduled and opportune lift), the actual distance flown and the actual time in the air, as well as other information.

C. DATA STRUCTURE

The computer system which collects this data is located at CHNAVRES Headquarters in New Orleans, Louisiana. A command-programmed DataBase Management System (DBMS) maintains extensive records on all demands for service as well as actual airlifts conducted. Within the DBMS environment, NALO can obtain any information it requires, in any format desired.

A DataBase Management System provides a random access capability to any file with which it communicates and allows the interactive combination or joining of file records to obtain specific information. The advantage of such a program is that data can be stored much more compactly and each file holds a minimum of information duplicated in other files. The underlying physical structure of the data is still the familiar files. However, the user does not communicate directly with the files and, in fact, may not know that they even exist. For example, a complete record of all data regarding one flight, from the original request messages to the Logistics Flight Report, can be obtained without the user ever accessing the files directly; yet it requires the DBMS to physically access all four files.

The NALO database resides on a disk pack which provides immediate use and access to any file. However, the transfer of data requires transferring the actual files. Since the actual programming for DataBase Management Systems is both hardware and language-implementation dependent, the programs themselves were not transferred to the Postgraduate School. While the ability to access the data as a full-capability data base would have been quite convenient, the time required to develop such a program seemed disproportionate to the advantages to be gained. Therefore, the data for the thesis was provided as four, independent, sequential files on magnetic tape. The contents of each of these files is described below.

1. <u>Flight Request File</u>

The Flight Request File contains complete information on all requests for service, irrespective of the final action taken on the request. It is compiled from the requests for service received from potential customers as described in Section B above. Appendix C, Table C.1, provides a complete record description with Field Titles, Field Size and a brief description of the data contained in each field. Although each record contains a large amount of data, there is no direct indication within this file of which aircraft, aircraft type, or base might have been assigned to service the request. There is a only a column which indicates whether the request was "regretted" or cancelled.

2. The Flight Advisory File

This file contains the information necessary to compose paragraph one of the Flight Advisory message. As discussed above, the information in this file is entered manually by the scheduling command. Appendix C, Table C.2, provides a detailed description of the record format, which is similar to the Flight Request File. The information in each of the records of this file is basically a summary of the information contained in the Flight Legs File, described below. Its primary value, in an analytical sense, is in gaining an overview of flights scheduled versus flight flown.

3. The Flight Lift File

This file contains the information necessary to compose paragraph two of the Flight Advisory message and contains details of each leg of the flight as scheduled. A detailed description of the record format for this file can be found in Appendix C, Table C.3, and follows the same style as the others. The information in this file would be of primary interest in an analysis of customer utilization of the system; ie, who is using the system, to what extent, and why.

4. The Logistics Flight Report File

As described above, this file contains the information on flights actually flown. A detailed description of this file record is shown in Appendix C, Table C.4. This file contains keyed fields connecting it with the Flight Request File and with the Flight Advisory and Flight Legs Files. It is the only file which is keyed to both of the other major files. It also provides, without requiring access to the other files, all the data necessary to analyze and understand the current operation of the Navy Air Logistics System.

D. SELECTION OF DATA

Because the Data Collection System has been undergoing continual change and refinement since it was installed in 1981, the consensus of both NALCOEP and NALO was that the Fiscal Year 82 data was incomplete and undependable. Thus, 1983 was selected because it represented the first complete fiscal year of relative stability, both in the slowing of major changes to the system and in the training of all the scheduling commands in the maintenance and use of the database.

The selection of a readily identifiable time interval was considered to be important to allow for future analysis and comparison, whether as a follow-on thesis effort or as an in-house effort on the part of NALO or NALCOEP. The Government Fiscal Year is an obvious choice of a time interval because it is readily accepted and identifiable. During initial discussions on which time interval was appropriate, there was some initial concerns within NALO as to whether there might be a drop in the number of flights due to insufficient funds at the end of a Fiscal Year, and/or an increase in the number of flights at the beginning of a Fiscal Year as more fuel funds and travel funds become available. The selection of the Fiscal Year was seen as a logical resolution since it has the advantage of restricting any such funding distortions to the endpoints of the time interval.

After eliminating records not dealing with the C-12 aircraft, a cursory examination of the data files was conducted. The usefulness of the Flight Request File was questionable. Without any indication of which base and/or which type of aircraft might have flown a regretted flight, analysis of unsatisfied demand would have been limited to overall totals. A Fortran program was written to obtain those totals and the results indicated a large number of unfilled requests from one particular location. While this might have indicated that one command was conscientious in its documentation of requests for service, subsequent discussion with the cognizant scheduler indicated that this was not the case. This particular command consistently submitted requests for service immediately before, and in many cases, after the requested departure time. The command maintained small aircraft, such as Cessnas, which were outside the control of the Navy Air Logistics System and the scheduler believed that these late requests were an effort to manipulate the system database to justify their continued possession and use of these small aircraft. This made the veracity of the Flight Request File sufficiently questionable to eliminate its use for further statistical analysis without a validation of the service requests. Such validation would have required interviewing all commands whose flight requests were rejected. Such an effort would not have made a significant contribution to the preliminary analyses being conducted and was deferred for a follow-on thesis effort.

The Flight Advisory and Flight Lift Files, while providing a very detailed picture of the intended flight, were missing information such as time and distance which was necessary to understand current system operation. However, because of the keyed fields referred to above, one file contained all the desired information in a single record and led to the elimination of these two files from further consideration. In terms of understanding the operation of the system, it was obvious that the most useful information was available in the Logistics Flight Report File. It provided air time, mileage, origin, and destination for each leg directly and the elapsed clock time and several additional pieces of information could be easily computed for each flight. This file will be used for all subsequent analysis in this thesis.

E. CHAPTER SUMMARY

This chapter has looked at the C-12 aircraft. Its capabilities and limitations provide, in some sense, bounds on what can be expected in the data. The chapter has also examined how the data is collected and how it is structured. The strengths and weaknesses of the data as it is structured has been reviewed and the Logistics Flight Report File has been identified as the best file to analyze.

III. INITIAL ANALYSIS

Chapter II defined the structure of the available data. The purpose of this chapter is data analysis. It seemed appropriate to begin with a type of top-down analysis, using some techniques from the field of Exploratory Data Analysis. The purpose was to get a feel for the data and determine what information was available and useful. A natural result of this type of analysis is an indication of directions for additional investigation. Throughout this chapter, questions will be raised and outliers in the data will be highlighted. However, the further investigation and resolution of these issues will be deferred until Chapter IV.

A. AGGREGATION OF DATA

The basic unit of data is the flight leg, defined in Chapter II. The Logistics Flight Record File had 12,361 individual records, each describing one leg flown by a C-12 aircraft. This level of detail would be quite useful in some follow-on studies such as determining high-density traffic patterns or investigations dealing with the effects of weather on flight times and/or actual distance flown. However, it is much too detailed for the current level of analysis.

The next higher level data structure is a round-trip flight and the first step in the analysis was to combine the individual records into such flight records. This reduced the size of the database to 3,858 records. At this level of aggregation, the following information was also available, either by direct summation of the original fields or by computation after the aggregation has been accomplished.

- Mission Number
- Aircraft Serial Number
- Date and time of flight commencement
- Date and time of flight termination
- Number of hours in the air
- Number of hours on the ground
- Number of hours of delay time in excess of normal terminal service
- Total number of legs in the flight
- Total distance travelled
- Number of passenger-carrying legs
- Distance flown with passengers aboard
- Number of passenger miles flown
- Passenger capacity
- Utilization of passenger capacity
- Number of cargo-carrying legs (arbitrarily determined as those legs with cargo and without passengers)
- Distance flown on cargo legs
- Cargo weight-miles flown
- Cargo capacity

- Utilization of cargo capacity

- Number of deadhead legs. As used by the system, a deadhead leg is flown by the same crew in the same aircraft but without passengers or cargo. This is not the same definition as that used in commercial aviation.

- Distance flown in deadhead state.

The next step was to sort the data by home base because they are also potential sites for locating new aircraft. The following information was available for analysis after the second step.

- Numbers of aircraft at each base

- Total number of flights flown by each base during Fiscal Year 1983

- Total flight time for each base

- Total number of passengers moved by each base

- Total passenger miles flown by each base

- Total cargo tonnage moved by each base

- Total cargo weight-miles flown by each base

- Total number of legs flown by each base

- Total passenger-carrying legs flown by each base

- Total cargo-only legs flown by each base

- Total deadhead distance flown by each base

- Average passenger capacity utilization for each base

- Average number of legs per flight for each base

- Average cost per passenger-mile for each base; the sum of total cost per flight, based on $120.00 per hour current cost figure provided by NALCOEP, divided by the number of flights

- Average percentage of deadhead flight time for each base; the sum of the actual ratio of deadhead flight flight hours per flights, divided by the number of flights

- Average deadhead cost per flight for each base; the deadhead time per flight times the cost per hour ($120), summed over all flights and then divided by the number of flights

- Average number of flights per month for each base; the total number of flights for 1983, divided by the number of months the base was operational

- Average total elapsed time hours per month for each base; the sum of all flight hours during 1983, divided by the number of months the base was operational

- Average number of flights per month per aircraft for each base; the average number of flights per month divided by the number of Aircraft assigned to that base

- Average elapsed time hours per month per aircraft for each base; the average elapsed time hours per month divided by the number of aircraft assigned

As indicated in Chapter II.A, the C-12 aircraft is seldom used for cargo transportation. Less than three percent (330 records) of the Logistics Flight Report File were cargo-only legs. As a result, the data on cargo-only flights will be disregarded in further analysis. Additionally, many of the variables above portray the same information. Total passenger miles and total passengers tend to be functions of the number of aircraft at a base, as are total flights, total flight time, total legs, total passenger legs and total deadhead legs. The information in these variables can be better represented, in some cases, by computed variables such as average cost, average flights per month, or average deadhead cost per flight. Using similar reasoning, the data can be reduced to the following variables with one value for each of the 23 bases.

- Number of aircraft assigned; a discrete variable with only three possible values; 1, 2, or 3

- Average flights per month; a functionally continuous variable ranging from 6.75 to 25.17

- Average flights per month per aircraft; a continuous variable ranging from 5.29 to 15.50

- Average elapsed time (hours) per month; a continuous variable ranging from 64.98 to 344.33

- Average elapsed time (hours) per month per aircraft; a continuous variable ranging from 41.53 to 127.29

- Average percentage of deadhead distance; a continuous variable computed by summing the ratio of deadhead distance to total distance for each flight and dividing by the total number of flights. It ranges from 0.12 to 0.30.

- Average deadhead cost per flight; a continuous variable computed by multiplying actual deadhead air time by the current cost per hour, summing over all flights for each base and dividing by the total number of flights for that base. This variable ranges from $80.02 to $186.13

- Average passenger capacity utilization; a continuous variable computed by summing over all legs not used strictly for cargo for each base and dividing by the total number of legs for each base. This variable ranges from 0.37 to 0.93

- Average cost per passenger-mile; a continuous variable ranging from $0.195 to $0.333

- Average number of legs per flight; a continuous variable ranging from 2.83 to 4.75

This data can be displayed as a 23 x 10 matrix. It is shown with row and column titles in Appendix D.

B. ANALYSIS TECHNIQUES

Having reduced the data to a manageable and understandable format, the analysis began with a broad view of the data to see if possible correlations or indications of directions for further investigation were suggested. Graphs of some of the information involving the entire database were constructed to check initial assumptions and expectations. This was followed by construction of a Draftsman's Plot. Then some Coded Scatterplots were constructed to clarify questions arising from the Draftsman's Plot. Each of these techniques are discussed below.

1. Initial Investigations

The crew-time limitations of the C-12 aircraft imply that a multi-modal distribution of flight times could be expected and it might also be expected that a vast majority of flights would have a duration of less than one day. However, that is not at all clear from the raw data. Figure 2 displays a histogram with a class interval of 15 minutes. It clearly shows a distribution that is exactly as expected. The distribution is highly skewed with a vast majority of flights lasting between three and 12 hours. Additional modes can be seen at about 30 hours and again at about 45 hours. Flights beyond 75 hours were not shown because there were too few of them to register on a graph showing the entire range of values. These three modes are consistent with safety regulations which require a 17 hour

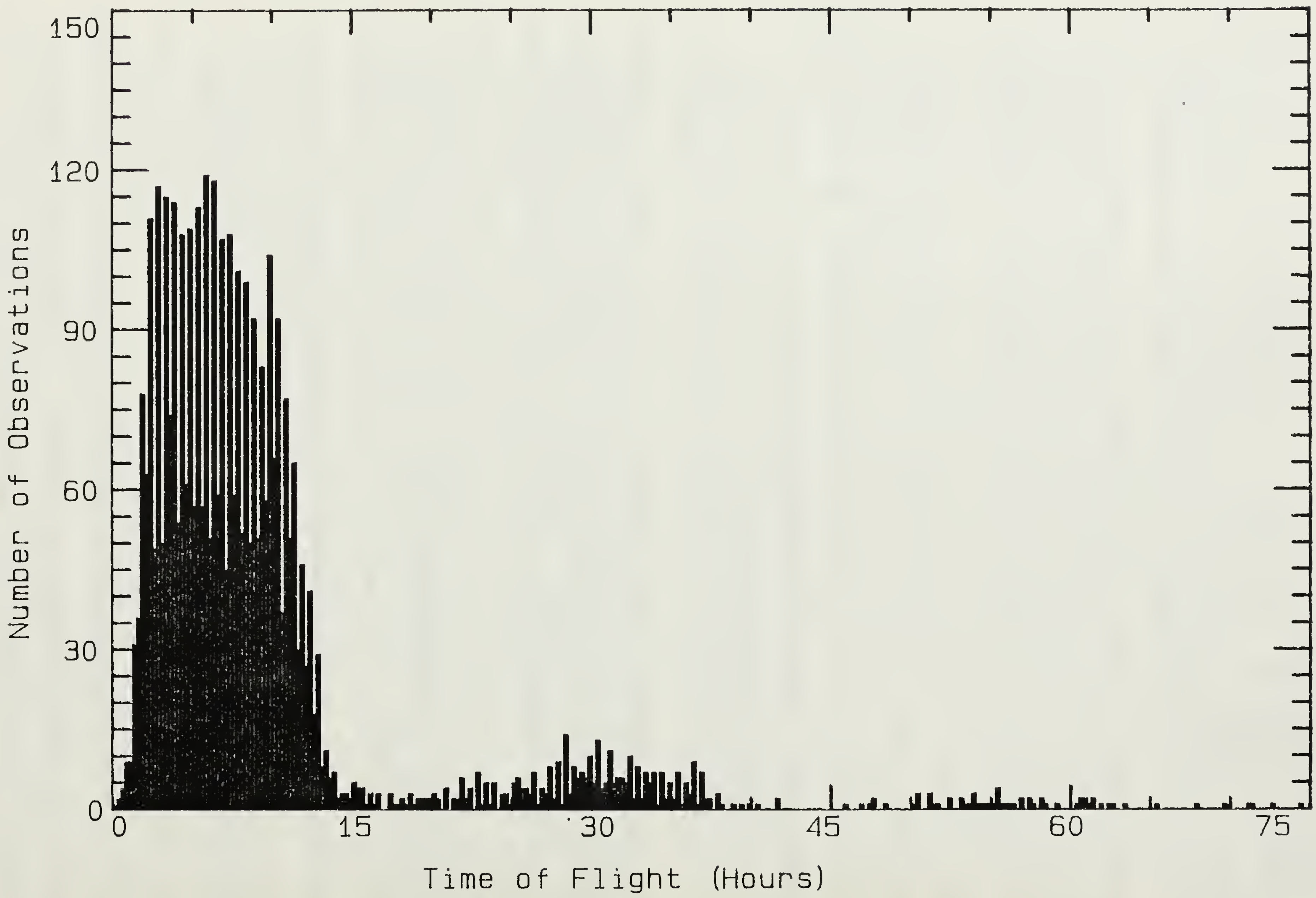


Figure 2 - Frequency Histogram of Hours per Flight

rest stop whenever the flight crew will be on duty for more than 12 hours. Total elapsed flight time, as defined above, includes these rest stops since the aircraft is away from home base and unavailable for additional use even if another crew was available. The existence of flights during the period from 12 to 24 hours a reflects flights requiring a round-trip flight time in excess of 12 hours and flights requiring an overnight stop on official business even though a crew rest stop would not have been required.

The next issue investigated was the question of possible correlation between flight time and distance. It is unlikely that any combination of readily available data could be used to predict the total flight time. Actual times are affected by altitude, weather, trade winds, fuel conservation policies, and perhaps, by other variables as well. The length of the flight, particularly those measured in days, might well be a function of the grade and rank of the passenger being serviced. The primary interest in this issue is to identify any unexpected trends or anomolies. Figure 3 displays a scatterplot of elapsed flight time versus total distance flown. It is easy to see a general trend for flights lasting less than 12 hours. A line with slope 1/200 appears to fit that portion of the graph quite well and reflects the average airspeed of the C-12 aircraft... 200 miles per hour. Additional groupings for elapsed time can be seen which reflect the second and third

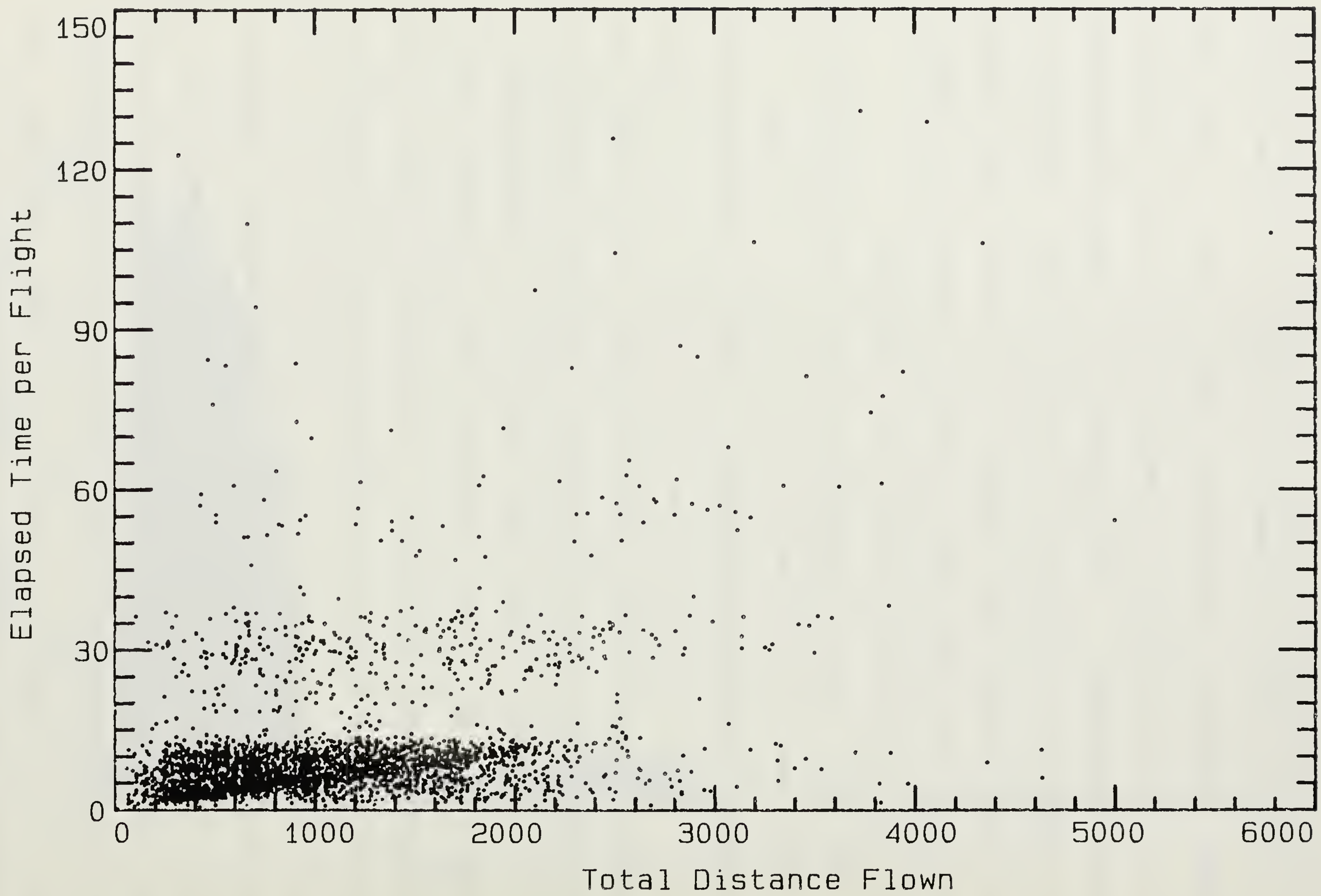


Figure 3 - Scatterplot of Elapsed Time vs Total Distance Flown

modes in Figure 2, and obviously indicate flights with one and two overnight rest stops. These groupings appear to also correlate with the average airspeed of the C-12.

In Chapter II, it was stated that a flight could consist of as few as one leg and that some flights had in excess of ten legs. However, it is difficult to determine from the raw data just how the number of legs per flight is distributed. Figure 4 shows that a vast majority of the flights consist of from two to four legs, with few flights above eight legs or less than two legs. The 42 flights consisting of only one leg are worth noting because a flight is normally a round-trip. These one-leg flights may indicate that the rest of the flight is missing from the database or, more likely, they may indicate flights in which the aircraft was away from home base so long that a new flight number was assigned when it finally returned. An examination of the database did not produce a clear explanation of the phenomenon. However, since these flights represented only about one percent of the data, the matter was not persued.

Another question of interest is whether the average number of flights flown by the system varies from month to month. Different analysis techniques might be appropriate if the number of flights flown, or the hours flown, remained constant or displayed a pronounced trend throughout the Fiscal Year.

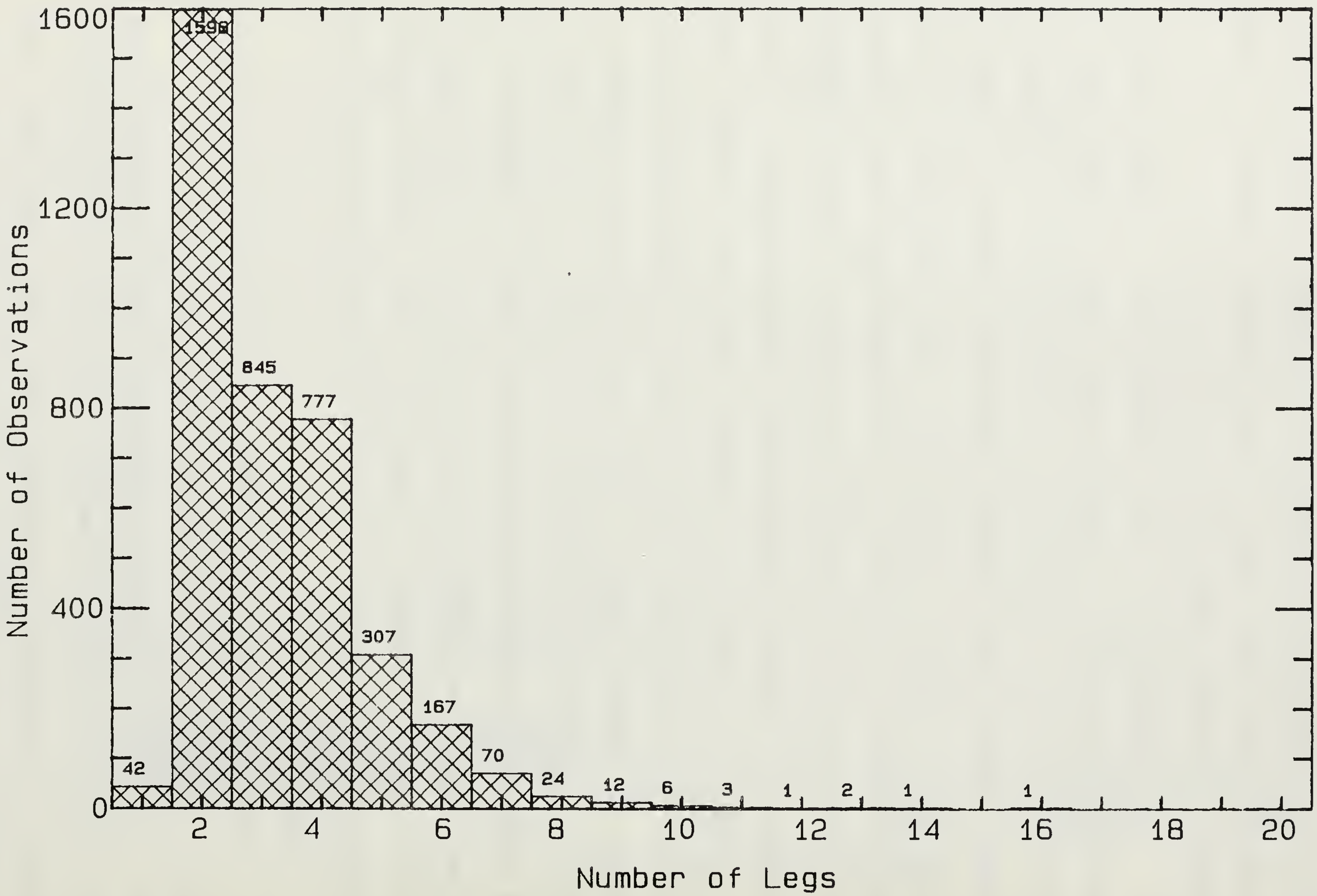
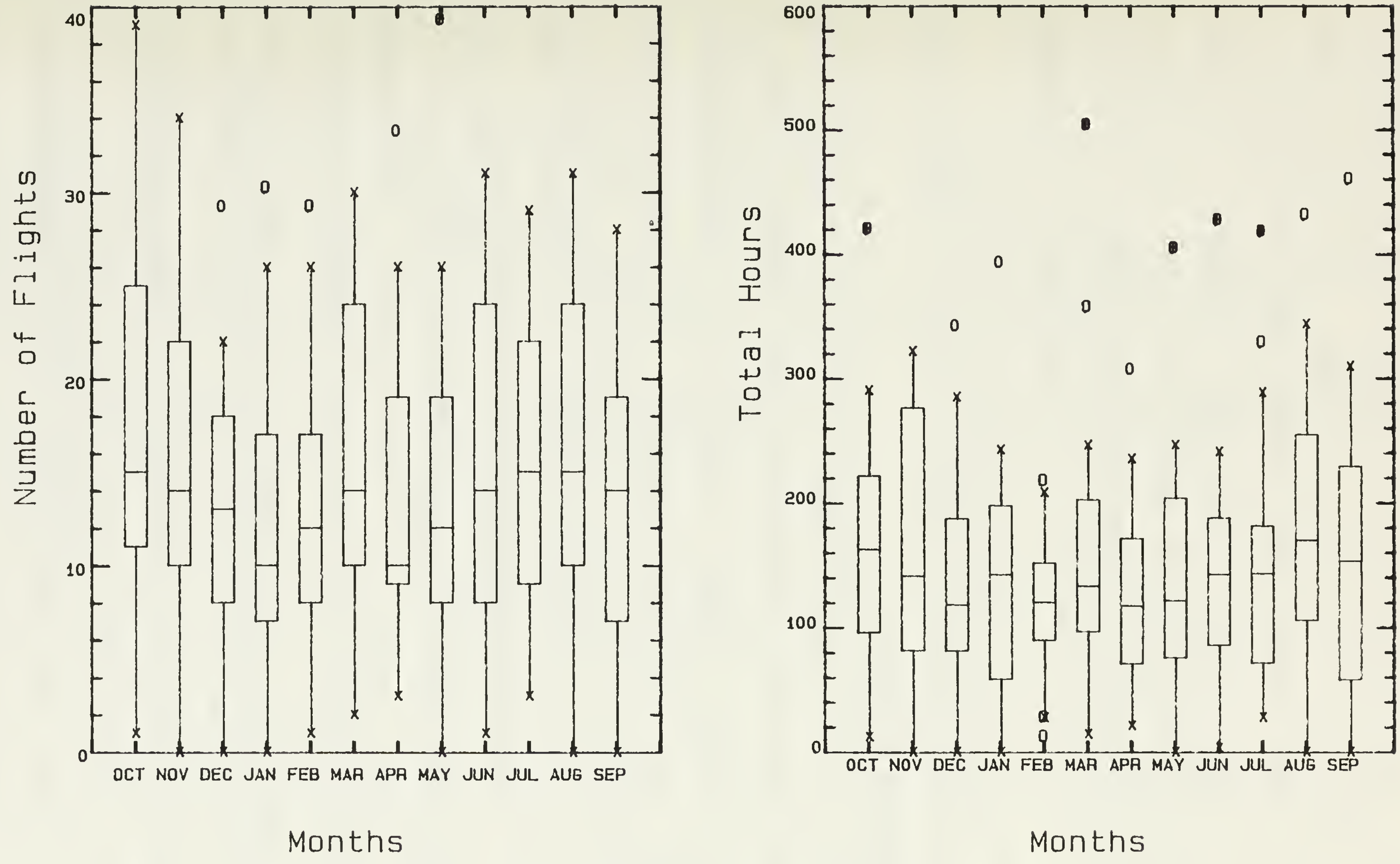


Figure 4 - Frequency Histogram of Legs per Flight



(a)

(b)

Figure 5 -- Multiple Box and Whisker Plots

Box and Whisker Plots provide an excellent method of obtaining this information at a glance. Detailed information on Box and Whisker Plots, their construction and the information they provide may be found in Appendix E. Figure 5a displays multiple box and whisker plots for the number of flights each month of the Fiscal Year and Figure 5b displays the same information for the total hours flown each month. Considerable variability is obvious without the need for further testing. However, no seasonal trend is discernable.

2. Draftsman's Plot

One of the best methods of obtaining a broad overview of the individual variables in a data sample is through a Draftsman's Plot. Thomas, in Appendix A of his Master's Thesis [Ref. 9], presents an excellent technical discussion of the Draftsman's Plot and its advantages. Briefly, a Draftsman's Plot is a 'matrix' of small scatterplots. Each variable is represented by a both row and a column. Thus when viewed as a whole, the Draftsman's plot shows the plot of every variable versus every other variable. For example, the upper left plot of Figure F.2 in Appendix F shows a standard scatterplot of average flights per month per aircraft versus average flights per month. Each point corresponds to the value of the pair of variables for one home base. In the case of the present database, a full display of such a plot would require 90 individual scatterplots, a very large display even given the small size of the individual plots. However, 45 of the individual plots are diagonally mirror images of each other. Therefore, only a half display is presented in this thesis. Even with this reduction, legibility requires the use of several pages to display the plot, so it has been placed in Appendix F. Individual scatterplots of interest from this appendix are reproduced in Figure 6.

The first thing of interest in Appendix F is the large number of plots with points randomly scattered suggesting that there is no correlation between most pairs of variables. This is not unusual however; it should not be expected that all variables would show a correlation. The following seven plots, Figure 6, exhibit possible trends and will be investigated further in Chapter IV. They are:

- Average number of flights per month per aircraft versus average number of flights per month;

- Average number of hours per month per aircraft versus average number of flights per month;

- Average hours per month versus average number of flights per month;

- Average deadhead cost per flight versus average number of flights per month;

- Average percentage of deadhead distance versus average deadhead cost per flight;

- Average number of legs per flight versus average deadhead cost per flight;

- Average passenger capacity utilization versus average percentage of deadhead distance.

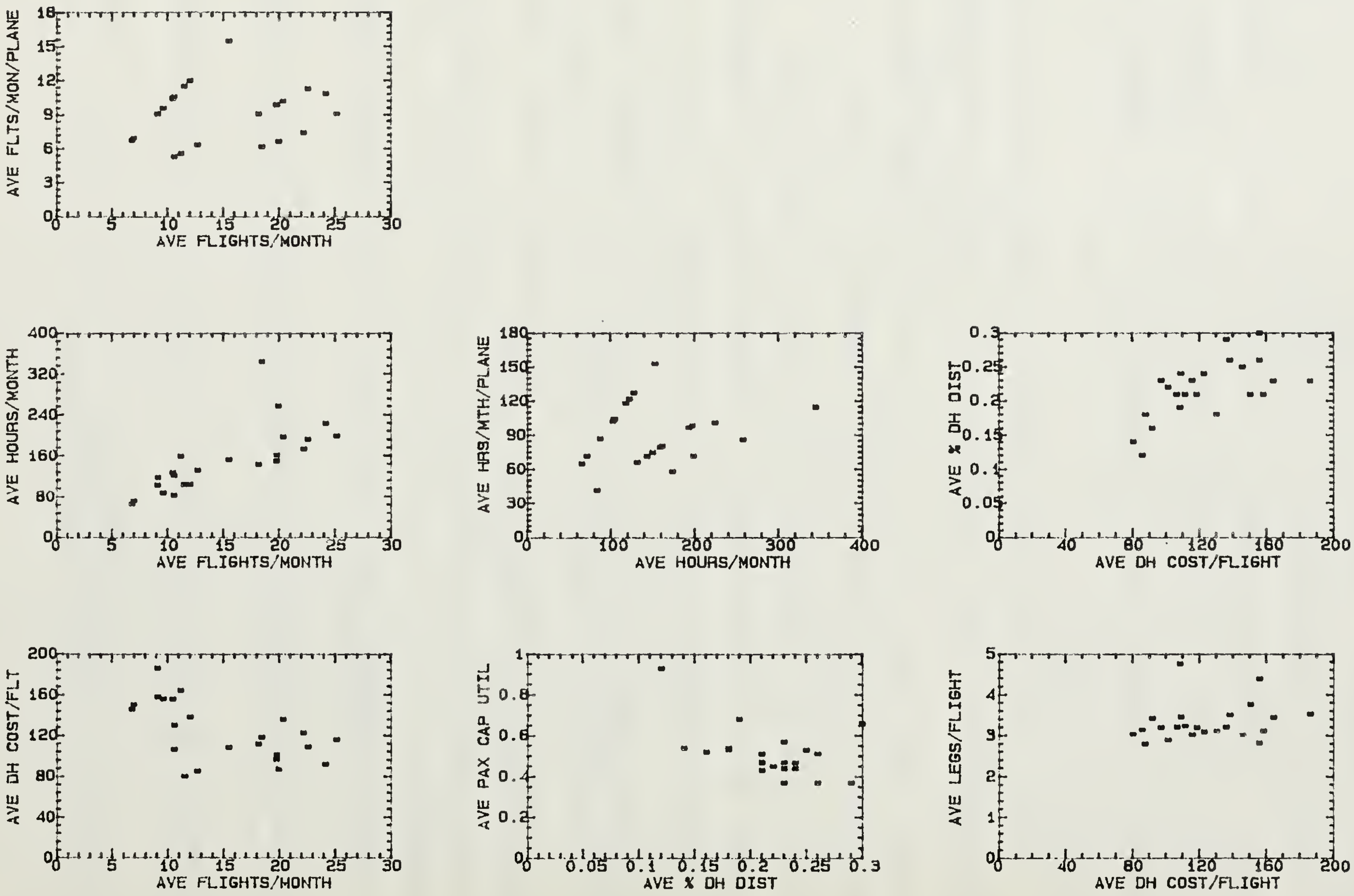


Figure 6 - Plots with Possible Correlation

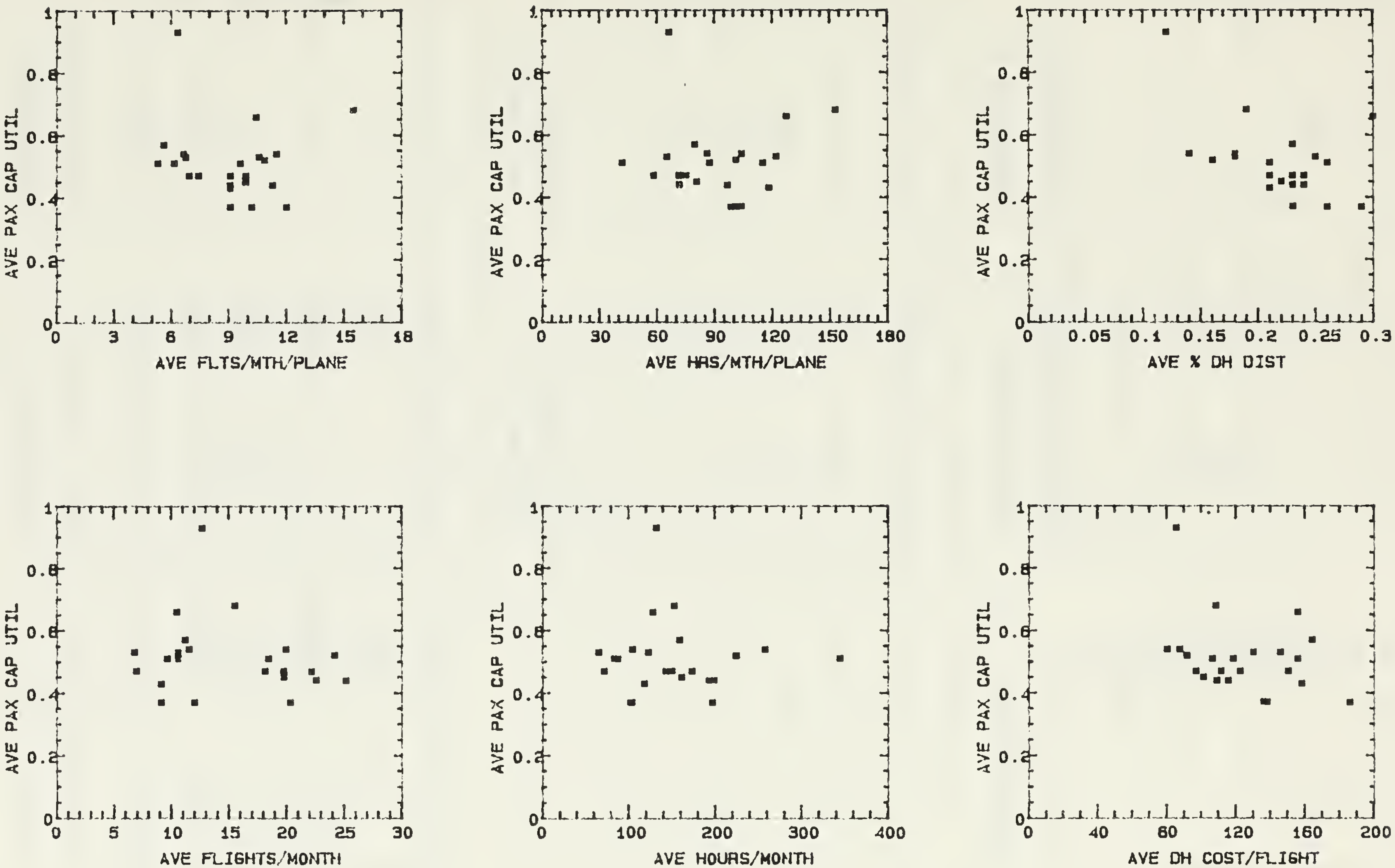


Figure 7 - Average Passenger Capacity Utilization

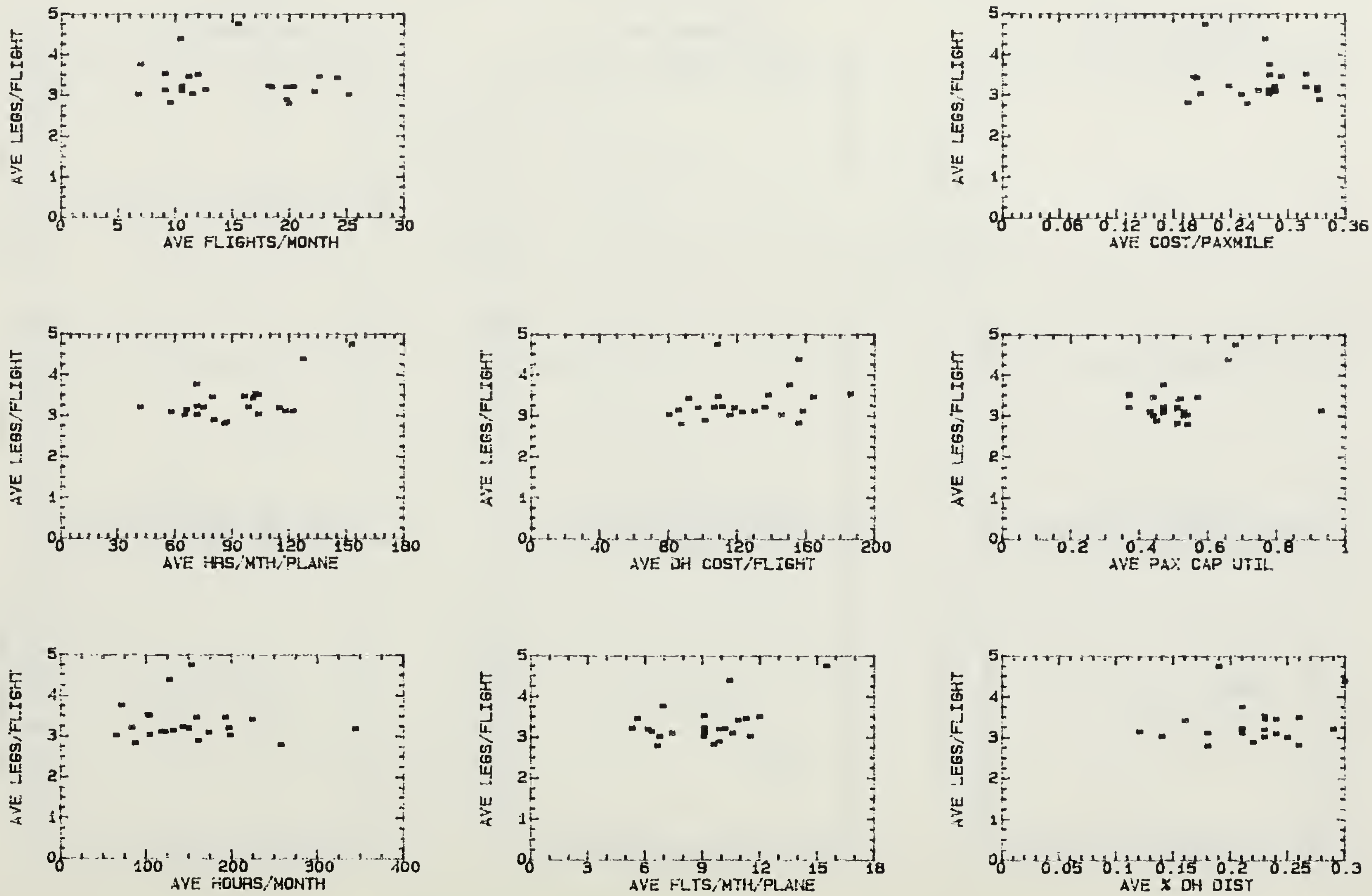


Figure 8 - Average Number of Legs per Flight

Next we look at the entire row of Appendix F having average capacity utilization as the ordinate. This entire row, reproduced in Figure 7, shows one value well above the others. Similarly, the row having average number of legs per flight on the ordinate and displayed in Figure 8, shows two values well above the others. The reasons for these 'outliers' will be investigated further in Chapter IV.

3. Analysis of Coded Scatterplots

The simple enlargement of the scatterplots of interest will not reveal any additional information. However, coding the points (bases) with the number of aircraft at each introduces a visible means for considering this as a third variable without needing to explore three-dimensional graphics displays. Thus, different symbols are used for each base depending on the number of planes assigned to it. The graphs can then be examined for the potential effects of the two plotted variables on the number of planes assigned - or visa versa.

a. Variable Pairs Stratified by the Number of Planes

Figure 9 presents two Coded Scatterplots which show data strongly stratified by the number of aircraft. In each case, a measure of performance per aircraft is plotted against a measure of total base performance. In both plots, the lines visible in the Draftsman's Plot divide themselves

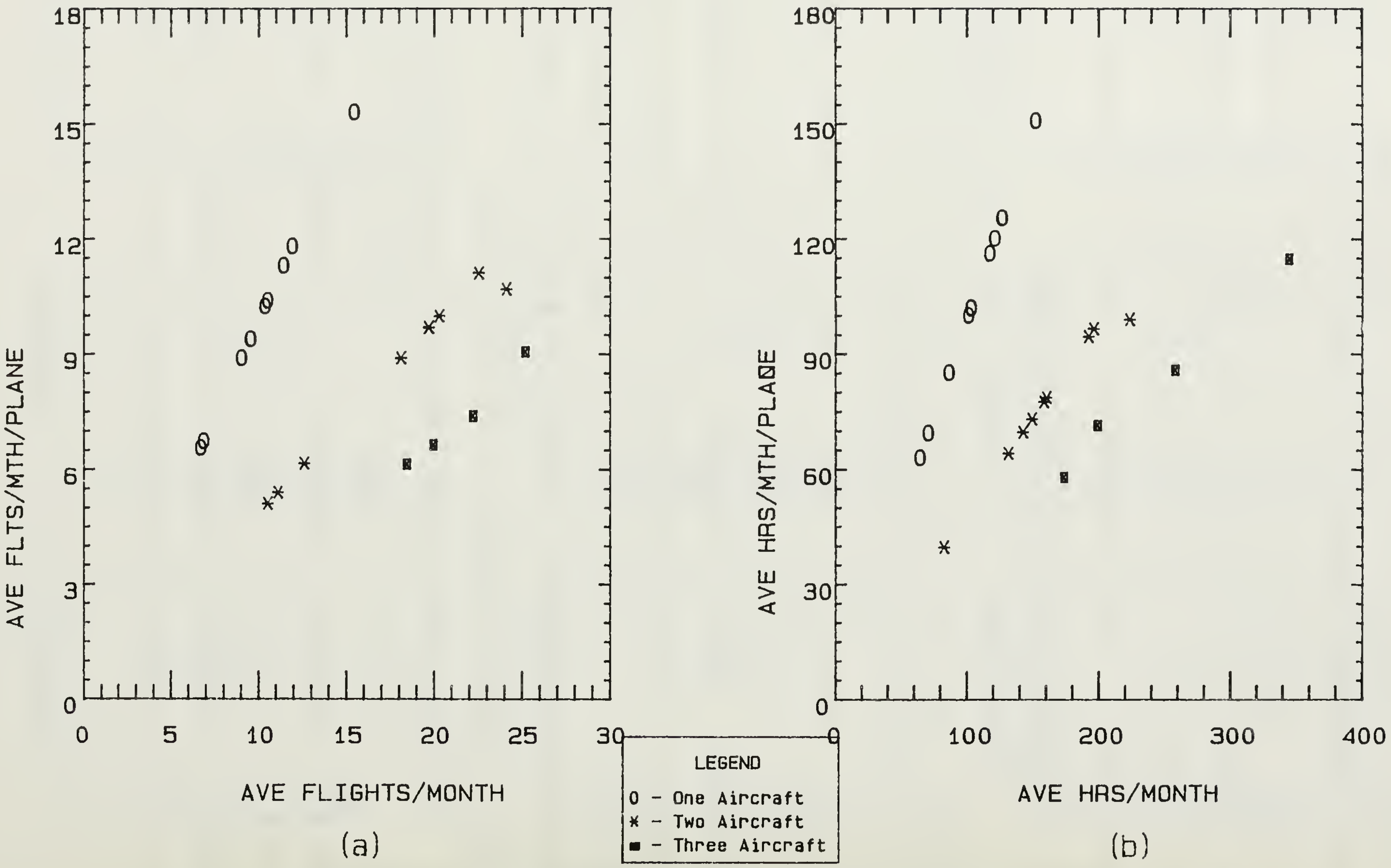


Figure 9 - Plots Stratified by Number of Aircraft

into the number of aircraft assigned to each base. A closer examination of the variables of interest indicate a direct correlation:

- Average hours or flights per month divided by the number of aircraft assigned equals the average hours or flights per month per aircraft.

They are obviously of no further interest.

b. Variable Pairs Involving Deadhead Data.

Four variable pairs from the Draftsman's Plot, all stratified by the number of aircraft and involving data about deadhead legs in one form or another, indicated potential trends. The Coded Scatterplots are shown in Figure 10.

Figure 10a, average deadhead cost per flight versus average number of flights per month, tends to support an intuitive feeling that the average deadhead cost per flight should decline as more flights are flown. Additionally, it appears that there may be some grouping by the number of aircraft assigned to the base, particularly between those bases with only one aircraft and those bases with more than one aircraft.

In Figure 10b, average deadhead cost per flight versus average percentage of deadhead distance, a strong positive correlation is evident. Again, this is consistent with an intuitive expectation of what should be the case with these two variables. However, there appears to be no pattern regarding the number of aircraft assigned.

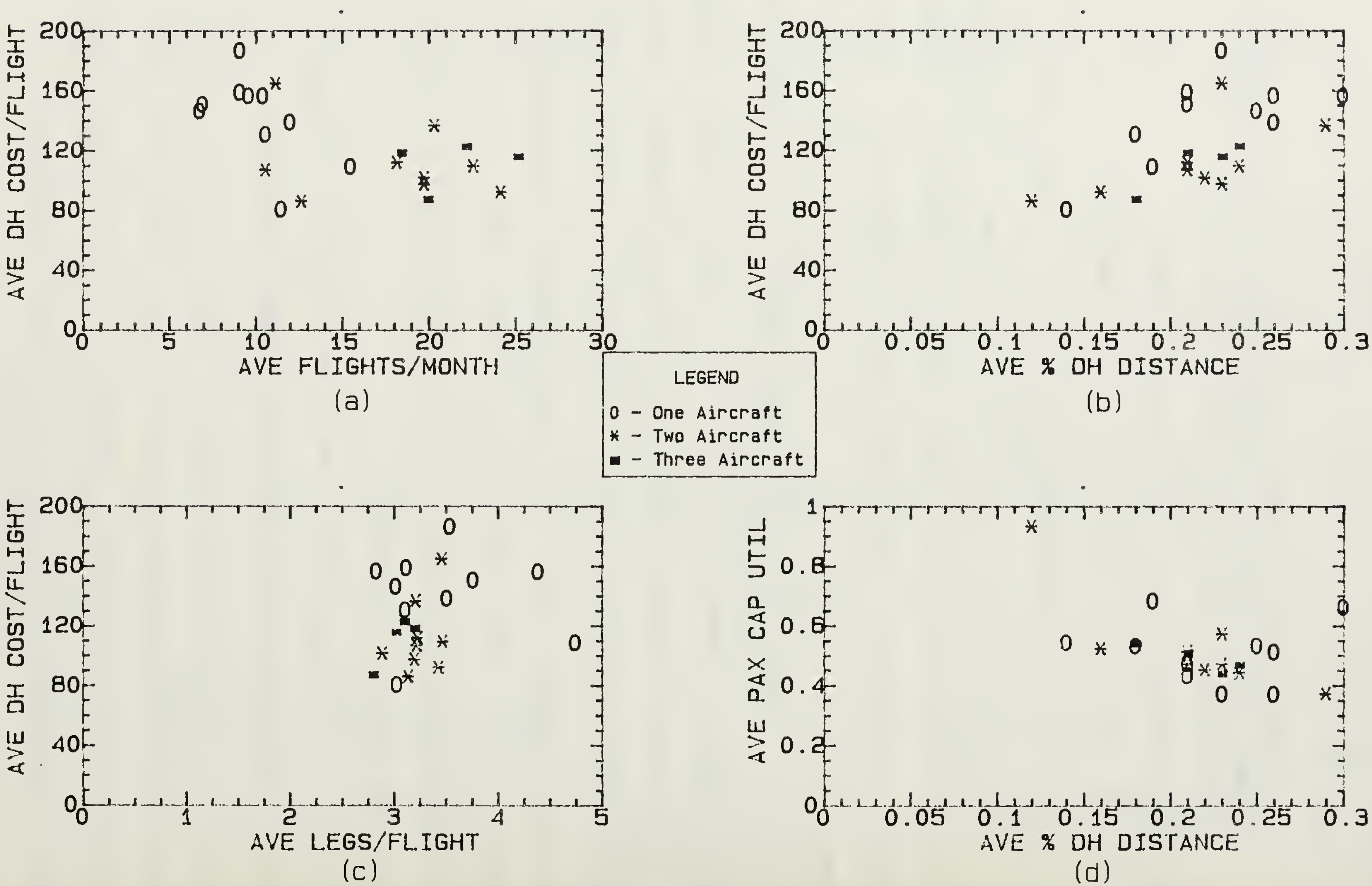


Figure 10 - Deadhead Information, Coded by Number of Aircraft

Figure 10c, average deadhead cost per flight versus average number of legs per flight appears to show a strong grouping but does not exhibit much trend across the graph. This is one of the series of plots discussed in Section 2 above where further investigation of outliers appears needed. The axes have been reversed from Figure 8 to allow easier visual comparison with the other graphs in Figure 10 and the outliers are now to the right of the graph rather than on the top. However, the labelling has produced an additional piece of information for that investigation - both outliers are bases with only one aircraft. There is some evidence of grouping by the number of assigned aircraft, particularly at the bases with three aircraft. This will be reexamined in Chapter IV after other graphs have been analyzed.

Figure 10d, average passenger capacity utilization versus average percentage of deadhead distance, is difficult to analyze visually because of the outliers. Disregarding the endpoints of zero and 100 percent capacity utilization, there is neither an intuitive nor a computational connection between the variables. However, it appears that average capacity utilization decreases as the average percentage of deadhead distance increases. No grouping by number of aircraft assigned is evident.

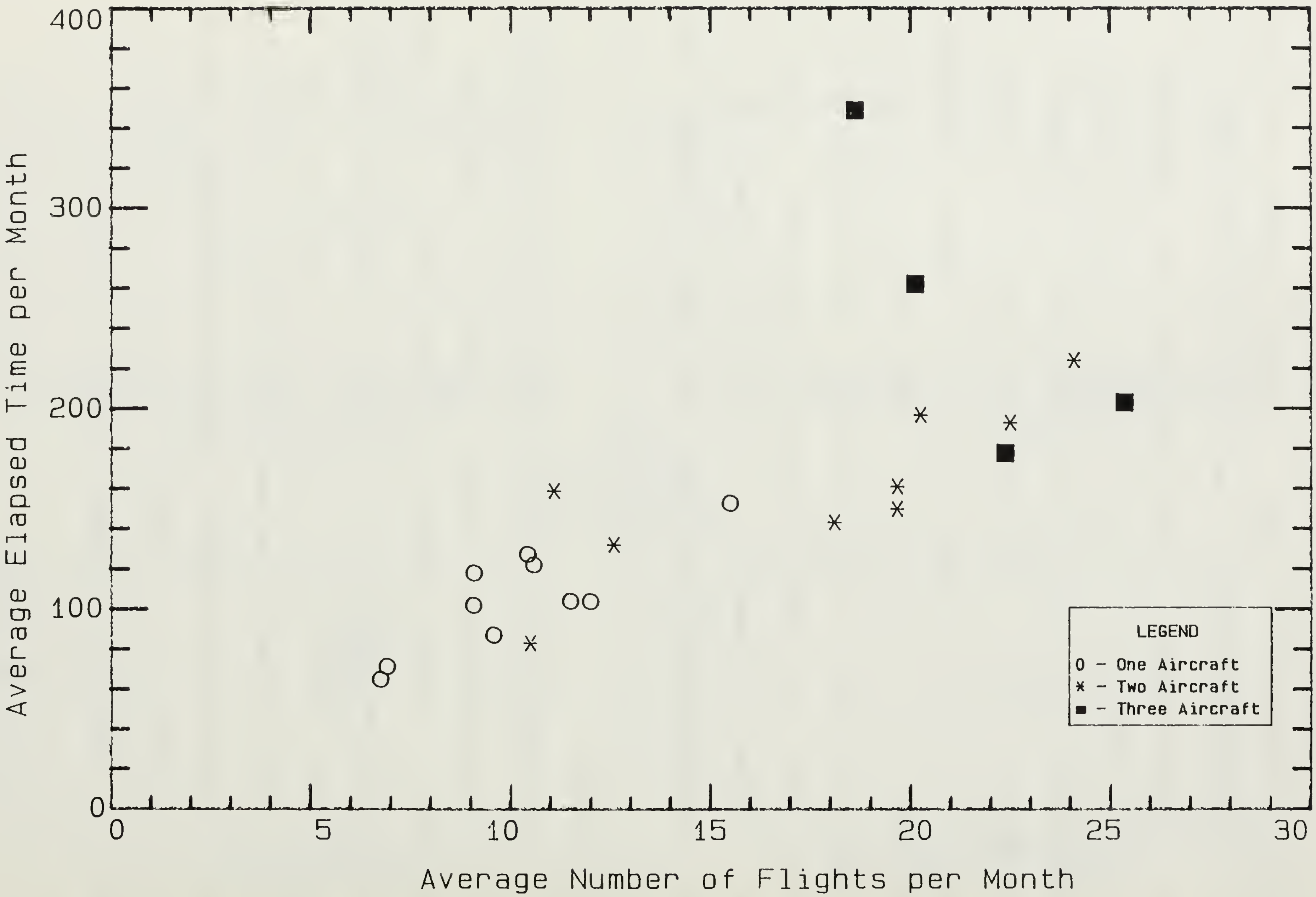


Figure 11 - Coded Scatterplot - Hours per Month vs Flights per Month

c. Variable Pairs involving Hours versus Flights.

Although many of the variables that have been examined are useful in determining how efficiently the system is operating, the variables now under consideration appear to have the greatest potential for describing how the system should operate. Intuitively, both the number of flights each base flies and the average operating hours of each aircraft should be correlated. As Figure 11 shows, there is indeed a strong positive correlation between the two coordinate variables. However, there is even more information being provided. The groupings by numbers of aircraft tend to overlap as the coordinate values increase. If, on the other hand, each base was operating at approximately the same efficiency, a strong grouping by the number of aircraft assigned should be expected. This overlapping suggests that some bases are more efficient than others. In particular, there is one base with only one aircraft assigned which has a significantly better performance than other one-aircraft bases and two two-aircraft bases appear to be doing the same work as those bases with three aircraft. At the other extreme, three two-aircraft bases appear to be noticeably less efficient than other bases with the same number of aircraft. Finally, the grouping for bases with three aircraft assigned appears highly variable.

The next step is to determine which points are associated with which bases and investigate why specific bases have consistently different performance than the rest of the bases with the same number of aircraft.

C. CHAPTER SUMMARY

This chapter has made use of several initial data analysis techniques to identify variables to consider further. In particular, Draftsman's Plots have pointed out several variable pairs with strong correlation and Coded Scatterplots have disclosed some outliers in the data. All of these aspects will be considered in the next chapter.

IV. DETAILED ANALYSIS RESULTS

Chapter III suggested several aspects the data which should be considered in more detail. This chapter examines these aspects and discusses both the methods used in the detailed analysis and the results of the analysis.

A. VARIABLE PAIRS INVOLVING HOURS VERSUS FLIGHTS

As discussed in Chapter III.B.3.c, the most intuitively satisfying indication of how well the system is operating is to consider both the number of flights flown and the number of hours flown. Comparing these same two variables for each base with the same number of aircraft assigned should provide the most direct indication of relative efficiency between bases.

Figure 11 of Chapter III presented a plot involving Average Hours per Month Hours versus Average Flights per Month. While either annual totals or monthly averages would have been appropriate, two pieces of information discovered during the initial aggregation efforts lead to the conclusion that the plot of average hours per month versus average flights per month would provide the most accurate description of the system as it actually functioned in Fiscal Year 1983.

First, it was necessary to determine how many C-12 aircraft were assigned to which bases during each month of 1983. The inclusion in the Logistics Flight Record of the Bureau Serial Number of the aircraft flying a given leg provided a simple method to determine this required information. However, during this aggregation, an aircraft was discovered which appeared to spend approximately 20 percent of its time flying out of Jacksonville, Florida, and approximately 80 percent of its time flying out Norfolk, Virginia. Since the aircraft appeared at both bases throughout the year, a reassignment of assets was ruled out.

Second, it was discovered that Dallas, Texas, lost an aircraft on or about December 1, 1982. This aircraft seems to have subsequently disappeared from the database. Also on or about December 1, 1982, Glenview, Illinois, appears to have transferred one of its aircraft to Selfridge Air National Guard Base. Since the monthly average figures were computed based on the number of months the base was in operation, the monthly averages can take these changes into account while annual totals cannot.

Figure 12 recreates Figure 11 with a fourth piece of information added - each point is labelled with the name of the base whose data it represents. The numbers in parentheses for Jacksonville and Norfolk show the effective number of aircraft assigned to the each base as a result of the one aircraft discussed above which split its time

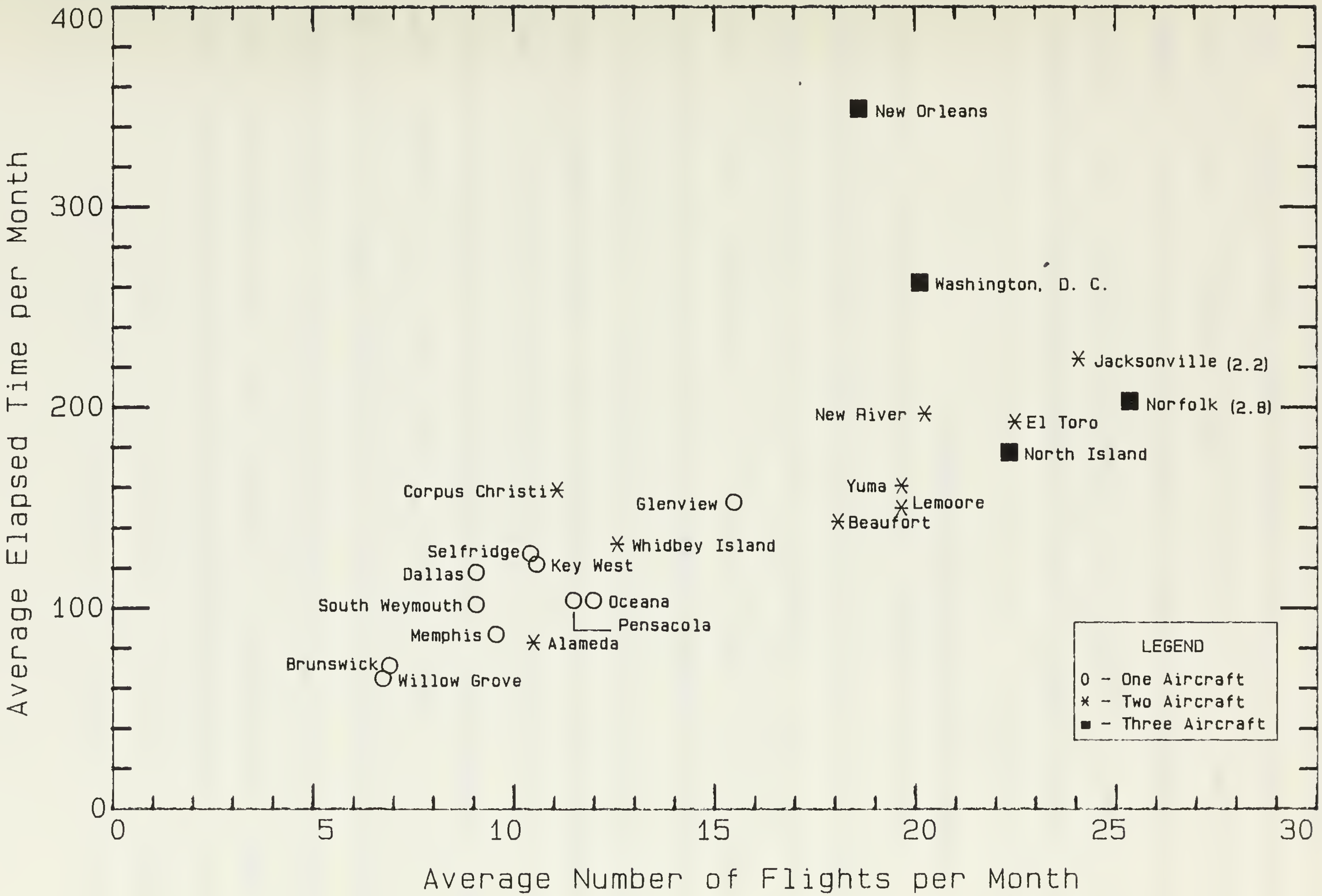


Figure 12 - Coded Scatterplot - Hours per Month vs Flights per Month

between those two bases. This additional labelling suggests specific bases for which effectiveness seems unusual. These include Alameda, California; Corpus Christi, Texas; Whidbey Island, Washington; Glenview, Illinois; El Toro, California; North Island, California; Brunswick, Maine; and Willow Grove, Pennsylvania. Each of these bases will be examined in detail below.

1. Naval Air Station Alameda

The two aircraft assigned to the Naval Air Station, Alameda, are scheduled by NALCOEP, and the Operations Officer for that command is one of the pilots regularly assigned by the base to fly C-12 missions. An in-depth investigation of the database for Alameda was conducted before discussing Figure 12 with NALCOEP. An examination of the flight records for Alameda did not disclose any obvious problems, there were flights by both aircraft in every month. When Figure 12 was shown to the Operations Officer [Ref. 10], he explained that Alameda was at that time experiencing difficulties in obtaining crews to fly the aircraft. This functionally limited Alameda to approximately 80 hours per month, a figure which the command itself pointed out could be easily conducted with only one aircraft.

2. Glenview, Whidbey Island, and Corpus Christi

Glenview and Corpus Christi are scheduled by NALO in New Orleans, Louisiana, while Whidbey Island is scheduled by NALCOEP. During the discussions with the NALCOEP Operations Officer about Alameda, Whidbey Island's position on the plot in Figure 12 was also discussed. Here again, the database had appeared to be complete, and there appeared to be no obvious reason for a base with two assigned aircraft to perform as if it only needed one. NALCOEP indicated that this was a demand related problem and that although two aircraft were not utilized efficiently, the loss of one aircraft would result in an increase in unfilled demand. It would also have a significant adverse impact on morale and training as well as on administrative support in the area. While Whidbey Island does support larger aircraft such as the DC-9, the 90 passenger capacity of that aircraft makes it inefficient for transporting small groups of people. Additionally, the size of the aircraft limits the locations it can serve. The Whidbey Island area, somewhat isolated from the rest of the Naval community, includes the Pudget Sound Naval Shipyard and the Trident Submarine Base at Bangor. With the buildup of the Trident program, demand in the area is expected to increase and NALCOEP felt that two C-12 aircraft would continue to be required in Whidbey Island.

Flight records for Glenview and Corpus Christi were also examined without discovering any of the problems mentioned above. Discussions were then conducted with the scheduler at NALO in an attempt to discover reasons for the relative performance of these two bases [Ref. 11]. Although it proved to be somewhat difficult by telephone to convey the information contained in Figure 12, the following facts were established. First, the situation at Corpus Christi is very similar to Whidbey Island... too much demand for one aircraft but not enough demand to keep two aircraft busy. Corpus Christi also supports the DC-9 aircraft, but again the aircraft has efficiency and base support limitations. There was no feel on the part of the scheduler as to whether business was increasing or decreasing in the Corpus Christi area.

On the other hand, Glenview has one aircraft which appears to represent about the maximum performance capability for one aircraft. The scheduler indicated that he regularly "worked the hell out of that (Glenview) aircraft." [Ref. 11] Although Glenview is also somewhat isolated from the bulk of the Navy community, there is a large volume of Naval Reserve business in the midwest. Several bases in the area support the larger DC-9 aircraft, but the bulk of small passenger transportation in the Reserves is assigned to Glenview, the only major Navy base in the area with small aircraft.

3. Low Demand, One Aircraft Bases

Two bases can be seen in the lower left-hand corner of Figure 12. Brunswick, Maine, and Willow Grove, Pennsylvania, are both scheduled by NALO. Discussions with the scheduler [Ref. 11] indicated that both bases have a very small customer base consisting primarily of reserve activities. The elimination of aircraft from these two bases would drastically curtail any administrative travel and increase "Navy Active Duty for Training" travel expenses.

4. The Boundary Between Two and Three Aircraft

Figure 12 is much less clear when considering the difference between two and three aircraft. The differences between North Island and El Toro tend to diffuse the boundary between two and three aircraft. Schedulers for the aircraft at El Toro, a Marine Corps Air Station scheduled by Commander Marine Corp Air Bases West (COMCABWEST), maintained that they were unable to meet all requests for service with only two aircraft, a statement which could not be verified without obtaining a new tape file.

NALCOEP, the scheduler for North Island could offer no concrete reasoning for the performance of the three aircraft assigned to Naval Air Station North Island, relative to the other bases with three aircraft. It was generally felt that part of the performance might be affected by the presence of two T-39 aircraft in San Diego.

The T-39 is a seven-passenger jet aircraft with a higher airspeed and longer range. Unfortunately, it is reputed to have a lower mean time between failures than the C-12 aircraft, and NALCOEP felt that three C-12 aircraft were necessary to absorb the demand created by the higher downtime associated with the T-39. This issue was not examined in any depth because it surfaced too late in the analysis for the author to obtain the data necessary for a full investigation of the phenomenon.

It is interesting to note that both Norfolk and North Island, which have lower average hours per month performance than the other two bases which have three C-12 aircraft also are major fleet concentration points which must deal with carrier task force deployments and returns. The demands placed on the Naval Air Logistics System by the massive movement of men and equipment when carriers gear up for, or return from, a deployment is well documented in the larger (C-9) aircraft data. It is possible that three C-12 aircraft may also be necessary to deal with the surge from this evolution.

It is fairly easy to visualize a straight line on Figure 12 running roughly between New Orleans, Washington, D. C., and Norfolk, Virginia. Such a line would also fit Jacksonville quite well. As discussed earlier, the Jacksonville and Norfolk bases appear to share five aircraft with a large majority of the flight time for the fifth aircraft devoted to Norfolk. This would seem to indicate that Jacksonville and Norfolk could have supported three aircraft each.

B. VARIABLE PAIRS INVOLVING DEADHEAD DATA.

The four plots presented in Figure 10 initially appeared to be of limited value. This is not changed by the coding of points by base names. In Figure 10a, average deadhead cost per flight versus average flights per month, there are three two-aircraft bases that appeared to have a lower relative performance when compared to the rest of the two-aircraft group. As could be surmised from Figure 12, these three bases were Alameda, Corpus Christi, and Whidbey Island. However, even with this additional labelling, that plot does not appear to offer any further information of interest.

In Chapter III it was pointed out that Figure 10b, average deadhead cost per flight versus average percentage of deadhead distance, appeared to follow what would be expected with those two variables. No obvious groupings by number of aircraft was evident. The additional information available from knowing which points correspond to which bases does not increase the usefulness of this plot and it will not be considered further.

Figure 10c, average deadhead cost per flight versus average number of legs per flight, displayed some possible grouping by number of assigned aircraft. However, the additional labelling did not provide any rational for such groupings. The one three aircraft base with the lower ordinate value was Washington, D. C., while the one aircraft base in the same vicinity was Pensacola. Neither of these bases has shown any tendency to stand out from their respective groups on other graphs. The reasons for this inconsistency did not appear to have a significant bearing on the question under investigation and were not pursued.

Chapter III briefly mentioned that in Figure 10d, the end points of the average capacity utilization appeared to be highly correlated with the corresponding values for the average percentage of deadhead distance, but dismissed these points as the only points where that happened. As an example, it is obvious that the average number of seats used per leg, and therefore per flight, can be changed without changing ratio of deadhead legs to total legs. Even with the additional labelling, no reason for the apparent correlation could be identified.

C. DRAFTSMAN'S PLOT OUTLIERS

The analysis of the Draftsman's Plot in Chapter III pointed out two variables with potential outliers. After identifying the bases involved, the flight records of these bases were examined and the results are summarized below.

1. Average Number of Legs per Flight

In reviewing the Draftsman's Plot, two bases consistently plotted higher average number of legs per flight than other bases against all other variables. Investigation revealed that these two bases were Glenview with an average of 4.75 legs per flight, and Selfridge with an average of 4.39 legs per flight. An examination of the flight records for these two bases did not reveal any reason for the higher average. In attempting to determine a reason for this behavior, an assumption was made that perhaps there were more legs because each leg was shorter. The average distance per leg was then computed for each of the bases and for the system as a whole. Glenview's average of 367.87 miles per leg and Selfridge's average of 356.06 miles per leg were both above the system average of 332.67 miles per leg. Both bases are in the midwest and there are no other small aircraft bases in the region, but there does not appear to be any other similarities except for the obvious 'Number of Aircraft'. Discussions with the scheduler in New Orleans [Ref. 11] produced no reasons for this anomoly. Since the same scheduler provides scheduling services for more than just these two bases, it would not appear to be unique to the scheduler and must therefore be assumed to be a geographic phenomenon.

2. Average Capacity Utilization

The outlier in Figure 7 was Whidbey Island. Flight Records were examined closely. Table C.4 discusses the Logistics Flight Report File data structure and defines passenger capacity as the number of passengers which could have been carried had the aircraft been full. In the database for Whidbey Island, this field consistently recorded less than the seven passengers the aircraft can normally carry. While this was the direct cause of the high utilization percentage, neither the database nor the scheduler, NALCOEP, could explain the reason for the reduced passenger capacity. It is possible that this lower figure was caused by using seats to hold small cargo. It could also be caused by damaged seats which were unusable. It could also reflect a misunderstanding on the use of the Logistics Flight Report form. No conclusions could be drawn from the information available in the database. However, the 93 percent capacity utilization for Whidbey Island must be viewed with some suspicion.

D. SUMMARY

This chapter has presented a detailed analyses of potentially fruitful aspects suggested in Chapter III for evaluating and comparing the efficiency of operations at the various bases. Plots were expanded and specific data points were identified as representing specific bases. Flight records were then closely examined and schedulers were interviewed. Where possible, justification for the number of aircraft assigned to a base was determined. The major plot of interest turned out to be average hours per month versus average flights per month with the number of aircraft assigned to each base also shown.

V. CONCLUSIONS AND RECOMMENDATIONS

The initial purpose of this thesis was to determine potential home bases for additional C-12 aircraft expected under a continuing five-year procurement plan. Since no previous analysis had been conducted, a top-down approach was taken. First, the organization of the Navy Air Logistics System was examined and the structure of the available data was discussed. The data was aggregated from individual legs to flights and then sorted by home base. Basic questions about the resulting database, such as the distribution of flight times and the distribution of the number of legs per flight were discussed using basic frequency histograms. Exploratory data analysis techniques, such as multiple Box and Whisker Plots and Draftsman's Plots, were then used to assess the data. Seven variable pairs were discovered which exhibited potential correlation and two individual variables displayed possible outliers. Coded Scatterplots, depicting the number of aircraft at each point, were used to look for correlation between data pairs and number of aircraft. After identifying bases with unusual behavior when compared to other bases with the same number of aircraft, detailed examination of the Logistics Flight Report File and discussions with the cognizant schedulers were used to determine reasons for such behavior.

Bases having potential outlier values in the variables of average capacity utilization and average number of legs per flight were identified and examined, but no reasons for the unusual behavior could be positively identified.

This chapter presents conclusions and recommendations for further study. However, the rich variety of operations and aircraft types that make up the entire system creates a pattern of interdependence which cannot be totally avoided. The conclusions which are drawn from the information presented here must necessarily be considered in that context.

A. CONCLUSIONS

The first and most obvious conclusion that can be drawn is that Naval Air Station Alameda appears to have one too many aircraft for the crews it can provide. The observation from NALCOEP that those aircraft can not be scheduled for more than a total of 80 hours per month is clearly depicted in the operating data. The aircraft stationed there are significantly underutilized and constitute wasted resources. Serious attempts should be made to obtain additional crews, perhaps even some NALO billets should be obtained. However, if this is not possible one of the aircraft should be transferred to another base where crews are available. This would allow better utilization of the aircraft and improve overall system performance. Additionally, if the aircraft were placed at a west coast base within reasonable flying time of Alameda, service to Alameda customers might actually be improved by increased use of the aircraft.

Second, Naval Air Station Glenview represents the maximum operating tempo feasible with one aircraft. Even the command responsible for scheduling that aircraft believes that no more can be done with it. The superior performance level of this aircraft is as noticeable as the substandard performance of the two aircraft at NAS Alameda. One of the recommendations for further study involves this aircraft.

Third, Naval Air Stations Whidbey Island and Corpus Christi probably represent the lowest acceptable operating level for two aircraft. The data regarding these two stations may be interpreted in various ways. Both stations should be monitored closely with regard to levels of demand. Any measureable drop in business should be followed by a transfer of one of the aircraft to another base.

Fourth, Naval Air Station North Island represents the minimum operating tempo which may justify three aircraft. A final decision on this matter may well depend on several other factors including the utilization of the T-39 aircraft or the demands of carrier evolutions and is outside the scope of this investigation.

Fifth, Naval Air Stations Jacksonville and Norfolk require additional monitoring with regard to demand levels. An increasing level of business could quickly outpace the "swing" aircraft arrangement use in Fiscal Year 1983. The operating tempo of the two bases could have supported three aircraft each during the period under investigation.

If a regression line was drawn on Figure 12 from the origin to approximately 320 hours per month (on the right axis), one might then establish a minimum point on the line for any number of aircraft by assuming that Brunswick and Willow Grove were located at the minimum for one aircraft. Multiplying these coordinates by the number of aircraft to be considered would then provide a minimum point on the regression line for that number of aircraft. A line at that point, drawn perpendicular to the regression line might provide a reasonable starting point in determining whether a base should have a specified number of aircraft. However, this can not be interpreted as a hard and fast rule. It could serve only as a rough rule of thumb useful for determining a place to start. Many other factors having nothing to do with flight hours and number of flights also affect the final decision.

Sixth, the next aircraft received under the five-year procurement plan should go to Glenview, followed by the assignment of a sixth aircraft to the Jacksonville or

Norfolk area. Further recommendations would be futile until additional lost customer studies are performed as discussed below.

Finally, a large amount of study remains to be done. This analysis has only scratched the surface. Directions for further study are recommended below.

B. RECOMMENDATIONS FOR FURTHER STUDY

Many more questions have been raised than were answered in this analysis and opportunities exist for further study and analysis. Some of the following recommendations could be best pursued by the Navy Air Logistics System and its subordinate commands. Others would best be pursued as the subjects of subsequent theses or faculty research.

Of critical importance is a study of system demand for service, particularly those demands which are not being met. Such a study should examine the geographic locations of origins and destinations for requested flights for potential new locations for C-12 home bases. This will require an in-depth analysis of the Flight Advisory File and Flight Request File for those flight requests which were not met. However, in view of the discussion in Chapter II.D, the validity of the Flight Requests must first be determined. Stratifying the Flight requests by the number of days or hours before (or after) the requested departure time should prove to be quite enlightening, as should stratification of rejected requests by the day of the week the flight was desired. Major recommendations concerning the location of additional assets can not be made without fully understanding the types of service demanded and the geographic spread of such demands, based on a database free of requests for service made after the service was needed.

Funding of customers to allow them to obtain alternative means of transportation when the system cannot provide service needs to be addressed. This issue was not raised in the analysis because it is obviously a major topic in its own right. However, many of the discussions with schedulers about aircraft assignments and decreasing service included this topic. The main contention was that for many of the system's passengers, if the flights are not available from the Navy Air Logistics System, the flights are not taken at all. However, this does not imply unnecessary travel. While commercial flights require the sponsoring command to pay for the airplane ticket and MAC flights are charged to the sponsoring command's travel funds, flights in the Air Logistics System are currently free for local commands. As the system now operates, if local commands had to start paying for travel to schools, in many cases the travel would not be performed and the schools would not be attended. While the cost per hour figure of $120.00 used in this analysis is strictly an accounting figure, it could be used impute a cost which the Navy is willing to pay to retain the opportunity for educational travel.

The interrelationships of the system need significantly better definition. How do multiple aircraft types serving the same geographic area interact? Could overall efficiency be increased by using smaller aircraft such as the C-12 as feeder aircraft to the larger planes such as the DC-9? Can this be done without beginning to schedule any or all of the aircraft ahead of time? Would system efficiency be increased by placing the C-12 into a squadron environment rather than assigning them as base aircraft as is currently done? Where should such squadrons be located? Would this increase deadhead time and cost? Would it decrease maintenance downtime and cost? The answer to these types of questions could potentially result in large-scale savings to the Navy.

Surge capability needs to addressed. The Navy is a military organization whose overall mission is to be ready for war. Can a system like the Navy Air Logistics System be equipped to perform capably in a wartime environment and still operate efficiently in a peacetime environment? On a smaller scale, how much excess system capacity is necessary to manage evolutions such as carrier onloads and offloads? Can the Navy afford this excess capacity? Would commercial charter for these evolutions be more cost-effective?

The cost of overextending the system should also be addressed. Currently, only one aircraft could possibly be considered overextended, but what would be the ultimate cost if that situation became more prevalent? Would more TAD funds be required to accomplish even minimal training? How much more? Would aircraft safety or corrosion control deteriorate?

The overall mission of the Navy Air Logistics System also needs to be reexamined. Justification for the current aircraft procurement program appears to have been done without significant input from the Air Logistics System. Written specification of uses for which the C-12 aircraft were purchased do not appear to be available within the system. Questions of policy regarding minimum service levels need to be formulated in detail and examined. The low demand at Brunswick and Willow Grove, for example, points out the need to determine a minimum demand criteria to justify permanent assignment of an aircraft. Additionally, one of the biggest single sources of inefficiency seems to be the requirement, spelled out in OPNAVINST 4631.2B, to avoid competition with the Military Airlift Command and commercial aviation. Intuitively, higher aircraft utilization and efficiency could be obtained with scheduled flights, a methodology that remains unused under current interpretations of the mission requirement.

C. FINAL OBSERVATION

It is paramount to Navy credibility that assets in all areas are used wisely and efficiently without unduly jeopardizing wartime capability. The logistics system within the Navy has been under intense fire in recent years for waste and inefficiency. As mentioned in Chapter I, part of the logistics system, the Navy Air Logistics System, has specifically been severely criticized for waste and inefficient use of assets. With critical analysis, this area appears to offer great potential to achieve significant savings.

APPENDIX A

Figure A.1
Typical Flight Request Message

```
UUUUUUUUUUU UUUUUUUUUUUUUUUUUUUUUUUUUU
U      U N C L A S S I F I E D      U
UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU

ROUTINE

R 020714Z AUG 84

FM NAVPGSCOL MONTEREY CA

TO NALCOEASTPAC ALAMEDA CA

INFO NALCOPAC PEARL HARBOR HI          NAVAIRLOGOFF NEW ORLEANS LA
NAS NORTH ISLAND CA

BT
UNCLAS  //N04631//

SUBJ: AIRLIFT REQUEST
LIFT: A/

1. UNIT: NAVPGSCOL/UIC:31405/
2.A. DEP ICAO:KMRY/PLACE:MONTEREY/
2.B. DESIRED:1922000884/EARLIEST:1919000884/
3.A. ARR ICAO:KNZY/PLACE:NORTH ISLA/
3.B. DESIRED:2023450884/REQUIRED:2001300884/

4. PUJC:244E/

5. PAX:40/BAG:2640/
7.A. REQ COORD: LCDR LONG AV 878-2116 OR 2441 NPS/

9. TRANSPORT OFFICERS TO VARIOUS BRIEFINGS SCHEDULED WITH
COMNAVSURFPAC, COMASWWINGPAC, AND COMSUBGRU FIVE IN SAN DIEGO
DURING THE PERIOD 20-23 AUG.
LIFT: B/

1. UNIT: NAVPGSCOL/UIC:31405/
2.A. DEP ICAO: KNZY/PLACE:NORTH ISLA/
2.B. DESIRED:2322000884/EARLIEST:2320000884/
3.A. ARR ICAO:KMRY/PLACE:MONTEREY/
3.B. DESIRED:2323450884/REQUIRED:2403000884/

4. PUJC:244E/

5. PAX:42/BAG:2772/
7.A. REQ COORD:CDR SHAW AV 878-2116 OR 2441 NPS/


DLVR:NALCOEASTPAC ALAMEDA CA(3)...ACT                        //63//

                                                 RTD:000-000/COPIES:0003

  218517/2187/215     1  OF  2   M1 0749   215/14:17Z    020714Z AUG 84
CSN:RAL00790  -                                    NAVPGSCOL MONTEREY CA

UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
U      U N C L A S S I F I E D      U
UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
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Figure A.2
Typical Flight Advisory Message

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UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
U     U N C L A S S I F I E D      U
UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU


PRIORITY  ROUTINE

P R 191957Z AUG 84

FM NALCOEASTPAC ALAMEDA CA

TO FLELOGSUPPRON FIVE SEVEN             NAS ALAMEDA CA
NAS NORTH ISLAND CA                     NAS MIRAMAR CA
NAS WHIDBEY ISLAND WA                   USS CONSTELLATION
COMCARAIRWING FIFTEEN                   NAVPGSCOL MONTEREY CA

INFO NAVAIRLOGOFF NEW ORLEANS LA        COMNAVAIRPAC SAN DIEGO CA
NALCOPAC PEARL HARBOR HI                FLELOGSUPPRON THREE ZERO
FLELOGSUPPRON FIVE FIVE                 AIRFERRON THREE ONE
NAVMTO NORFOLK VA                       COMCABEAST CHERRY PT NC
COMCABWEST EL TORO CA                   COMMATVAQWINGPAC WHIDBEY ISLAND WA
NALCOPACREP PUGET SOUND WA              COMFITAEWWINGPAC SAN DIEGO CA
NAVOCEANCOMDET ALAMEDA CA               COMCARGRU ONE
USS CARL VINSON                         CARAIRWING FIFTEEN
TACELRON ONE THREE ONE

BT
UNCLAS //N04631//

SUBJ: C9B FLIGHT ADVISORY (X)

1. VR-57 NORI/OPERATE FLT:KGD440750/C9B  /SECO:C/CALL SIGN NALO 50
ALL TIMES ZULU:0884/
LEG ETA    ICAO PLACE       ETD    LIFTS      APAX ACARGO
/00/ORIG  /KNZY/NORTH ISLA/232250/ABCDE       / 18/ 6300/
/01/240001/KMRY/MONTEREY C/240045/BCDE        / 60/ 6300/
/02/240115/KNGZ/ALAMEDA CA/240200/BCDEFGH     /  4/  250/
/03/240350/KNUW/WHIDBEY IS/240435/IJK         / 60/ 6300/
/04/240715/KNZY/NORTH ISLA/TERM  /            /  0/    0/

2. LIFT SECTION
:A /UNIT:NAVPOSGRAS/UIC:N31405/ORIG:NORTH ISLA/DEST:MONTEREY C/
REQ:NPS        /REQ DTG:02071408848 /PAX: 42/BAG: 2772/


DLVR:NALCOEASTPAC ALAMEDA CA(3)...ORIG
DLVR:FLELOGSUPPRON FIVE FIVE(4)...INFO
DLVR:NAVOCEANCOMDET ALAMEDA CA(1)...INFO

312(1)...ACT FOR NAS ALAMEDA CA(18)                       00953/ 3/0153
   00(1) 11(1) 111(1) 19(5) 30(1) 40(3) 50(1) 302(1) OOD(1)
   TFC-ANL(1) SUPO(1)

                                                    RTD:000-000/COPIES:0026
                                                 32
   324131/5644/232    1  OF  3   M1 0349   232/20:06Z    191957Z AUG 84
CSN:RAL00402                                        NALCOEASTPAC ALAMEDA CA

UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
U     U N C L A S S I F I E D      U
UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
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Figure A.2 (continued)

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UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
U    U N C L A S S I F I E D     U
UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU

CARGO:    0/CARGO CUBE:    0/PUJC:24AE/
REQ COORD: CDR SHAW AV 878-2116 OR 2441 NPS   /
:B /UNIT:NAS WHIDBE/UIC:N00620/ORIG:NORTH ISLA/DEST:WHIDBEY IS/
REQ:NAS WHID  /REQ DTG:1007140884B /PAX:  1/BAG:   40/
CARGO:    0/CARGO CUBE:    0/PUJC:45TD/
REQ COORD:AZ1 MARTINEZ AV 820-2413              /
:C /UNIT:NAS WHIDBE/UIC:N00620/ORIG:NORTH ISLA/9EST:WHIDBEY IS/
REQ:NAS WHID  /REQ DTG:1303420884B /PAX:  2/BAG:   80/
CARGO:    0/CARGO CUBE:    0/PUJC:44AE/
REQ COORD:  MSCS ROJO AV 820-2076 NAS WHIDBEY /
:D /UNIT:VAQ 131    /UIC:N09364/ORIG:NORTH ISLA/DEST:WHIDBEY IS/
REQ:CMVWP      /REQ DTG:1516370884G /PAX:  1/BAG:   40/
CARGO:    0/CARGO CUBE:    0/PUJC:45TD/
REQ COORD: SANDY WRIGHT, AV 820-2118   /
:E /UNIT:NAS WHIDBE/UIC:N00620/ORIG:NORTH ISLA/DEST:WHIDBEY IS/
REQ:NAS WHID  /REQ DTG:0903450884B /PAX:  1/BAG:   40/
CARGO:    0/CARGO CUBE:    0/PUJC:54AE/
REQ COORD:  DOTTIE CONNER AV 820-2345 NAS WHID/
:F /UNIT:CVW15      /UIC:N09747/ORIG:ALAMEDA CA/DEST:WHIDBEY IS/
REQ:CVW15      /REQ DTG:1600510884L /PAX: 54/BAG: 2160/
CARGO: 3250/CARGO CUBE: 300/PUJC:22FL/
REQ COORD:LCDR JUSTET,CVW-15,DEPLOYED          /
:G /UNIT:CVW15      /UIC:N09747/ORIG:ALAMEDA CA/DEST:WHIDBEY IS/
REQ:CVW15      /REQ DTG:1600510884H /PAX:  0/BAG:    0/
CARGO: 2800/CARGO CUBE: 250/PUJC:22FL/
REQ COORD: LCDR JUSTET,CVW-15,DEPLOYED         /
:H /UNIT:CVW15      /UIC:N09747/ORIG:ALAMEDA CA/DEST:NORTH ISLA/
REQ:CVW15      /REQ DTG:1600510884J /PAX:  2/BAG:   80/
CARGO:    0/CARGO CUBE:    0/PUJC:22FL/
REQ COORD:LC9R JUSTET,CVW-15,DEPLOYED          /
:I /UNIT:NAS WHIDBE/UIC:N00620/ORIG:WHIDBEY IS/DEST:NORTH ISLA/
REQ:NAS WHID  /REQ DTG:0903460884B /PAX:  2/BAG:   80/
CARGO:    0/CARGO CUBE:    0/PUJC:44AH/
REQ COORD:  LCDR BOLING AV 820-2128 NAS WHIDBE/
:J /UNIT:NAS MIRAMA/UIC:N60259/ORIG:WHIDBEY IS/$EST:NORTH ISLA/
REQ:NAS MIRMAR/REQ DTG:2500270784B /PAX:  2/BAG:   80/
CARGO:    0/CARGO CUBE:    0/PUJC:55TZ/
REQ COORD:ATC STEITZ AV 959-2187                /
:K /UNIT:CONSTELLAT/UIC:N03364/ORIG:WHIDBEY IS/DEST:NORTH ISLA/
REQ:CV64       /REQ DTG:0720140884A /PAX:  1/BAG:   40/
CARGO:    0/CARGO CUBE:    0/PUJC:45TD/
REQ COORD:  LCDR BAKER AV 951-5900              /

3.  PAX SHOW TIME IS ONE AND ONE HALF HOUR PRIOR TO SKED DEP NON-
COMPLIANCE MAY RESULT IN LOSS OF CONFIRMED STATUS.

4.  SEATS AVAIL SUBJECT TO PRIOR SPACE (A) UTILIZATION.



  324131/5644/232    2  OF  3   M1 0349   232/20:06Z    191957Z AUG 84
CSN:RAL00402                                    NALCOEASTPAC ALAMEDA CA

UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
U    U N C L A S S I F I E D     U
UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
```

APPENDIX B
Logistics Flight Record Form

OPNAV 4631/1 (9-78)
S/N 0107-LF-046-3105

LOGISTICS FLIGHT RECORD

Replaces 8ND-CRTSW 3760/1 (6-78)

COPIES ☐ of ☐

IMPORTANT

- **This form is to be filled out for any flight when carrying passengers or cargo. Logistics Aircraft Custodians (VR, Base Command, Admin. Support, COD, VOD) are also to include deadhead legs.**
- **Completed forms are to be reviewed for content and accuracy and mailed on a weekly basis to COMRESTACSUPPWINGLOG, 4400 Dauphine St., New Orleans, La. 70146, ATTN: LFR Processor. PH: AV 363-1182 or FTS 686-1182.**
- **Numbered tables for form completion are on reverse side.**

ENTER "X" FOR SUBMISSION OF CORRECTED REPORT ☐

MISSION IDENTIFICATION

This section to be completed for all copies of this record used to document an air logistics mission.

AIRCRAFT BUNO	AIRLIFT MISSION NO	AIRCRAFT MODEL		ORGANIZATION		Total FLT LEGS	FPC	Time Zone Code
	For Logistics ACFT Custodians		3M T/E Code	Short Title	3MOrgCode	(A)		

Must be filled. Use "Z" for GMT. For other zones refer to table one.

FLIGHT LEG DATA

(B) Flt Leg No	BASED ON TIME ZONE USED: TIME	DAY MO YR	LOCATION NAME (Spell Out)	ICAO or Ship I.D.	Scheduled Passengers/Cargo on Board: PAX	CARGO	Opportune Passengers/Cargo on Board: PAX	CARGO	Type Cargo Code Table 2 Pri Sec
	DEPART								
	ARRIVE								
	DEPART								
	ARRIVE								
	DEPART								
	ARRIVE								
	DEPART								
	ARRIVE								

FLIGHT LEG DATA – CONTINUATION

Below entries complete data required for each flight leg.

(B) FLT LEG NO	(C) LOAD CAPACITY: PAX	CARGO	LEG HOURS	LEG DISTANCE	DELAY CODES For Logistics Aircraft Custodians See Table 3
			.		
			.		
			.		
			.		

(A) Total number of flt. legs being reported on. For logistics acft. custodians this is the number of flt. legs for an assigned unique airlift mission number. If multiple forms required, use identical total on each. For VOD operations requiring multiple shuttles enter only the total number of those flt. legs when actually carrying pax/cargo.

(B) Number flt. legs sequentially. Line entries in the FLIGHT LEG DATA—CONTINUATION section and FLIGHT LEG REMARKS should have flt. leg numbers identical with corresponding line entries in the initial FLIGHT LEG DATA section. Multiple lines in the REMARKS may be used to amplify any single line entry in FLIGHT LEG DATA.

(C) Total capacity for each flt. leg (how much each of pax and cargo could have been carried). Additionally, for C-9B ACFT enter "SECO" code for this mission ☐

FLIGHT LEG REMARKS

(B) Flt Leg No	*(Enter plain language remarks as appropriate to amplify associated flight legs.)*

LOADMASTER'S RATE AND NAME	SIGNATURE	DATE
ACFT COMMANDERS GRADE AND NAME	SIGNATURE	DATE

APPENDIX C

Table C.1

Record Format - Flight Request File

Field Title	Field Size	Description
Date-Time-Group	10	Date/Time Group of message request or customer arrival at walk-up window.
Requestor-Lift	2	Two letter designation to separate and identify each flight requested.
Date-Time-Stamp	10	Date/Time Group of entry into the database.
Actual-Scheduler	2	Which scheduling activity actually scheduled the flight. Entered by the scheduling activities.
Request-Scheduler	2	Which scheduling activity received the original request for service.
Regret-Code	1	Reason for not scheduling the flight, from OPNAVINST 4631.2B.
Cancel-Code	1	Reason for cancelling an already scheduled flight, from OPNAVINST 4631.2B
Dep-ICAO-Code	4	Internat'l Air Carrier Organization Code for location of requested departure
Arr-ICAO-Code	4	Code for the location of required delivery
Arr-Desired-DTG	10	Date/Time Group of the requested arrival time.
Dep-Latest-DTG	10	Date/Time Group of the requested departure time.
Arr-Latest-DTG	10	Date/Time Group of the latest acceptable arrival time
PUJC	4	Priority and Purpose Codes, from OPNAVINST 4631.2B

Field Title	Field Size	Description
Passengers	3	Number of passengers for which transportation is requested.
Baggage-Weight	5	Weight of accompanied baggage to be flown.
Cargo-Weight	5	Total weight of unaccompanied cargo to be flown.
Cargo-Cubic-Feet	5	Total cubic feet of scheduled cargo shipment.
Cargo-Type-Codes	2	Codes used to indicate cargo that may require special handling such as hazardous, toxic, etc.
Largest-Single-Item	14	Length, height, width, and weight of largest single piece of cargo.
Heaviest-Single-Item	14	Same information on the heaviest single piece of cargo.
Request-Coordinator	36	Name and phone number of requestor's coordinator for flight.
Depart-Coordinator	36	Name and phone number of requestor's coordinator at actual departure.
Arrive-Coordinator	36	Name and phone number of requestor's coordinator at actual arrival.
VIP-Code	2	If a Senior Military Officer or civilian is to be transported, this code indicates grade and rank.
VIP-Name	15	Name of the Senior Officer/Civilian.
Remarks	36	Free-form for any additional info.
Modification-Counter	2	Indicates which modification of an original flight request.

Table C.2
Record Format - Flight Advisory File

Field Title	Field Size	Description
Mission-Designator	9	Scheduling Command's Flight number.
Leg-Designator	2	A number to designate which leg of the flight the data on the line refers to.
Date-Time-Group	10	Date/Time Group of outgoing message
Date-Time-Stamp	10	Date/Time Group of entry in DBMS.
Actual-Scheduler	2	Command scheduling the flight. Note that this may not be the scheduling command that received the initial request.
Cancel-Code	1	If this message is cancelling a flight for which a flight advisory message had been issued, this code indicates the reason for the cancellation.
Aircraft-Type	7	Type of aircraft scheduled to fly.
Aircraft-Config	1	Configuration of aircraft to be used. Applicable to DC-9, primarily
Est-Arr-DTG	10	Estimated arrival time at location indicated in record.
Est-Dep-DTG	10	Estimated departure time from same location.
Arr-ICAO-Code	4	Location to which estimated arrival and departure times apply.
Passengers	3	Number of seats available leaving the indicated location. Different from the number of passengers scheduled.

Field Title	Field Size	Description
Baggage-Weight	5	Pounds of baggage available leaving the indicated location. Different than the pounds of baggage scheduled for departure.
Cargo-Weight	5	Pounds of cargo available leaving the indicated location. Different than pounds scheduled for departure.
Cargo-Dimensions (4 fields)	35	See table C.1.
Modification-Counter	2	Indicates which modification of an flight advisory. Original message is modification 1.

Table C.3
Record Format - Flight Lift File

Field Title	Field Size	Description
Date-Time-Group	10	Departure time of lift.
Requestor-Lift	2	Matches a specific leg on the flight to a specific request on the original flight request.
Unit-ID-Code	6	Unit Identification Code (UIC) of requestor.
Mission-Designator	9	Scheduler assigned flight number.
Leg-Designator	2	Which leg of the flight this line or record refers to.
Scheduler-Lift	2	The scheduling command scheduling this lift.
Actual-Scheduler	2	The scheduling command scheduling this flight.
Cancel-Code	1	Reason for cancelling previously scheduling lift.
Orig-IACO-Code	4	Departure location code.
Dest-IACO-Code	4	Arrival location code.
Passengers	3	Seats available on this leg.
Baggage-Weight	5	Pounds of baggage available for use.
Cargo-Weight	5	Pounds of cargo available for use.
Cargo-Dimensions	4	Dimensions of unused cargo space.
PUJC	4	Applicable Priority and Purpose indicated in customer request.

Field Title	Field Size	Description
Coordinator-Info	36	Requestor coordinator name/phone
Unit-Lifted	10	Plain language short title of unit receiving service.
Modification-Counter	2	Indicates a modification to a previously scheduled lift.
Aircraft-Type	7	Not used in FY83 Data File.

Table C.4
Record Format - Logistics Flight Report File

Field Title	Field Size	Description
Mission-Designator	9	Scheduler assigned flight number.
Leg-Designator	2	Identification of specific leg of the flight.
Date-Time-Stamp	10	Date/Time Group when the record entered the database.
Aircraft-Buno	6	Aircraft Bureau Serial number.
Aircraft-Model	4	Aircraft Model and Type code.
Flight-Purpose-Codes	3	Self-Explanatory.
Time-Zone	1	Self-Explanatory.
Dep-DTG	10	Time of departure.
Arr-DTG	10	Time of arrival.
Dep-ICAO	4	Departure location code.
Arr-ICAO	4	Arrival location code.
SPAX	3	Number of scheduled passengers.
SCGO	5	Pounds of scheduled cargo.
OPAX	3	Number of opportune lift passengers
OCGO	5	Pounds of opportune lift cargo
Cargo-Codes	2	Cargo type codes
Load-Capacity-Pax	3	Total number of passenger that can be carried on the flight.
Load-Capacity-Cargo	5	Cargo capacity for flight.
Leg-Hours	3	Air time for leg in hours.
Leg-DX	4	Distance flown in miles.

APPENDIX D
RESULTS OF DATA AGGREGATION

Base	Number Aircraft	Ave Flts per Month	Ave Flts per Month per Plane	Ave Hours per Month	Ave Hours per Month per Plane	Average Deadhead Cost/Flight	Average Ratio DH Distance	Average Pass Capacity Utilization	Average Cost per PassMile	Average # Legs
Alameda	2	10.58	5.29	83.07	41.53	$ 106.39	0.21	0.51	$ 0.286	3.22
Beaufort	2	18.17	9.08	143.16	71.58	111.29	0.21	0.47	0.238	3.23
Brunswick	1	6.92	6.92	71.38	71.38	150.21	0.21	0.47	0.281	3.76
Corpus Christi	2	11.17	5.58	158.92	79.46	164.24	0.23	0.57	0.201	3.46
Dallas	1	9.08	9.08 (1)	118.04	101.18 (1)	158.29	0.21	0.43	0.269	3.12
El Toro	2	22.58	11.29	192.83	96.42	108.88	0.24	0.44	0.293	3.47
Glenview	1	15.50	15.50 (1)	152.75	130.93 (1)	108.35	0.19	0.68	0.213	4.75
Jacksonville	2	24.17	10.87 (2)	224.27	100.87 (2)	91.55	0.16	0.52	0.204	3.43
Key West	1	10.58	10.58	122.00	122.00	130.08	0.18	0.53	0.331	3.11
Lemoore	2	19.75	9.88	149.94	74.97	96.93	0.23	0.47	0.319	3.20
Memphis	1	9.58	9.58	87.09	87.09	155.91	0.26	0.51	0.195	2.83
New Orleans	3	18.42	6.14	344.33	114.78	118.37	0.21	0.51	0.286	3.20
New River	2	20.33	10.17	196.88	98.44	136.10	0.29	0.37	0.331	3.21
Norfolk	3	25.17	9.06 (2)	198.61	71.53 (2)	115.68	0.23	0.44	0.251	3.02
North Island	3	22.17	7.39	173.08	57.92	122.75	0.24	0.47	0.287	3.10
Oceana	1	12.00	12.00	103.83	103.83	138.10	0.26	0.37	0.281	3.51
Pensacola	1	11.50	11.50	103.97	103.97	80.02	0.14	0.54	0.208	3.01
Selfridge	1	10.43 (3)	10.43 (3)	127.29 (3)	127.29 (3)	155.92	0.30	0.66	0.276	4.39
South Weymouth	1	9.08	9.08	101.93	101.93	186.13	0.23	0.37	0.319	3.54
Washington, DC	3	19.92	6.64	257.75	85.92	87.31	0.18	0.54	0.257	2.80
Whidbey Island	2	12.67	6.33	132.08	66.04	85.47	0.12	0.93	0.280	3.14
Willow Grove	1	6.75	6.75	64.98	64.98	145.64	0.25	0.53	0.280	3.02
Yuma	2	19.75	9.88	161.04	80.52	101.09	0.22	0.45	0.333	2.89

NOTES:
1. Reflects transfer of assets on or about 1 December 1982.
2. Reflects 'swing' aircraft arrangement, 2.2 aircraft to Jacksonville and 2.8 aircraft to Norfolk.
3. Reflects startup of Selfridge on or about 1 February 1983.

APPENDIX E
Box and Whisker Plots

Box and whisker plots provide a rapid 'impression' of the distribution of a data sample, providing an excellent method of gaining an overview of the data when details are not necessary, or when several samples need to be compared. Chambers [Ref. 12] discusses the several parts of the Box and Whisker Plot in great detail. However, a brief summary of the parts of the plot are provided below.

The box itself is constructed to cover that portion of the sample between the upper and lower quartile, or the twenty-fifth and seventy-fifth percentile. The median is shown by a line or any other distinguishing mark. In a regular box and whisker plot, the width of the box has no significance. A comparison of the location of the median within the box can give a quick impression of the symmetry of the distribution.

The whiskers, or solid lines extending from the box, indicate the bulk of the mass in the tails of the distribution and give a visual indication of the spread of the data. A well balanced sample will have both an upper and lower whisker of approximately the same length while a highly skewed sample may have only one whisker. The length of each whisker is a function of an actual point in the sample as follows. The end of the upper line, or whisker, is that value in the sample which is less than or equal to the upper quartile plus the interquartile distance. The end of the lower whisker is that value in the sample which is greater than or equal to the lower quartile minus the interquartile distance. The interquartile distance is defined as the upper quartile minus the lower quartile.

In addition to the box and the whiskers, there may be individual points beyond the whiskers. These points may be either solid or blank. The blank circles indicate values between the end of the whisker and a theoretical value lying 1.5 interquartile distances above the upper quartile, or below the lower quartile. Solid circles reflect points outside this range and indicate data points that may be outliers and should be investigated.

APPENDIX F

The following pages present the original Draftsman's Plot of the variables used in this analysis. Each row of plot is labelled only once, on the far left side. Similarly, each column of plots is labelled only at the bottom of the column. To assist the reader in visualizing the complete Draftsman's Plot, the following pages are labelled as Part A, Part B, or Part C. They fit together as follows:

```
 ___________
I           I
I  Part A   I
I           I
 _______________________
I           I           I
I  Part B   I  Part C   I
I           I           I
 _______________________
```

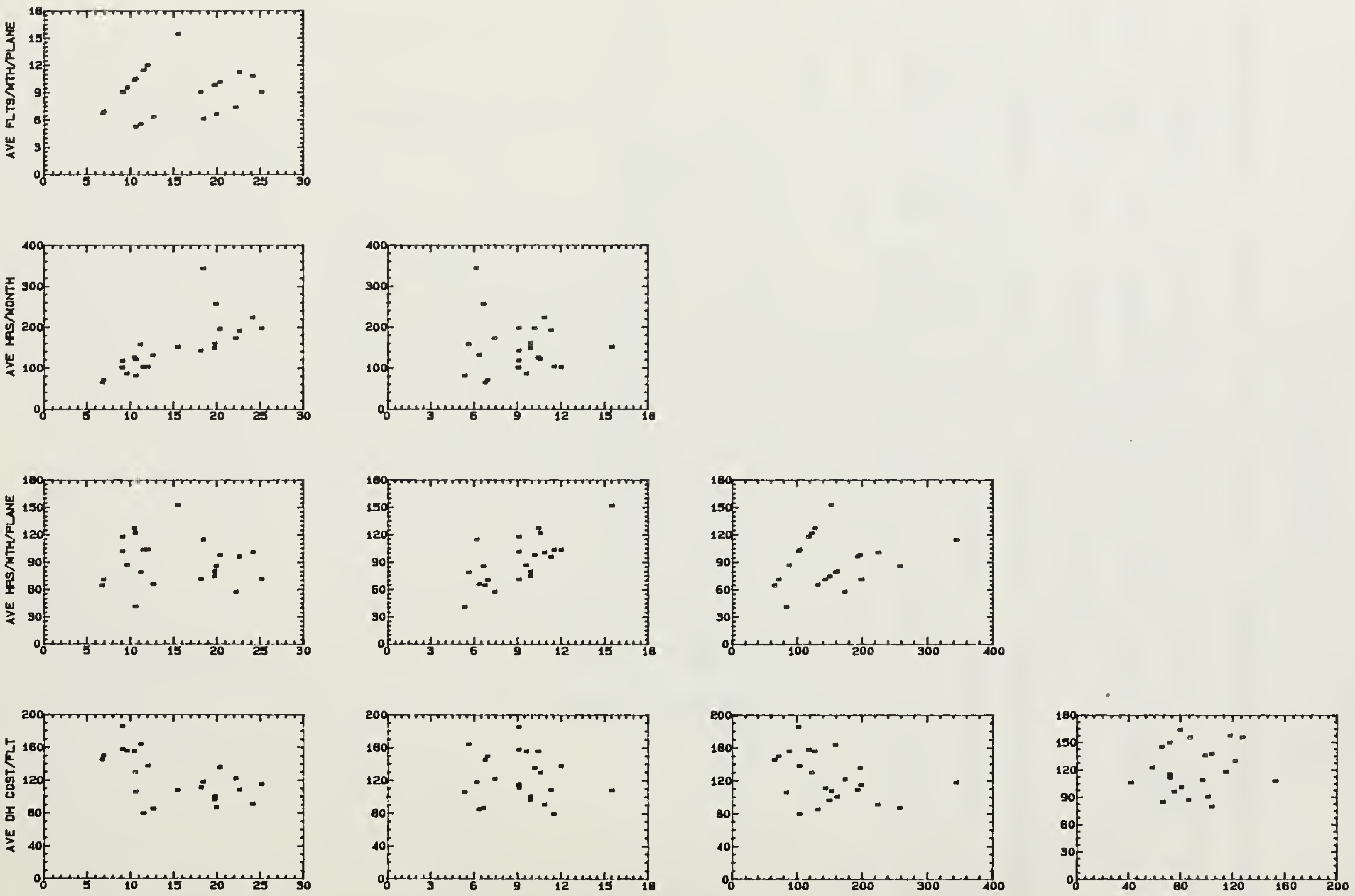

Figure F.1 - Original Draftsman's Plot - Part A

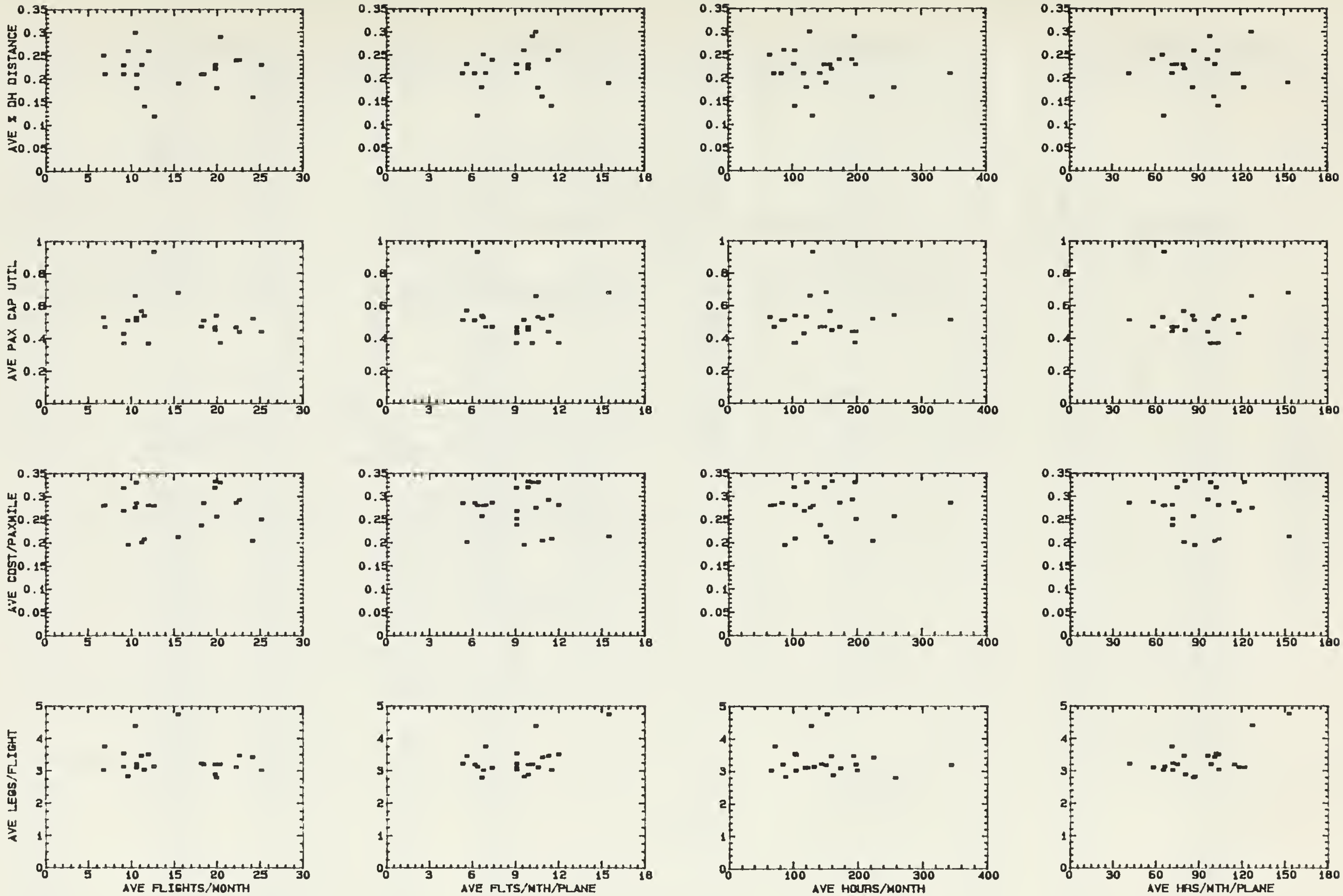

Figure F.2 - Original Draftsman's Plot - Part B

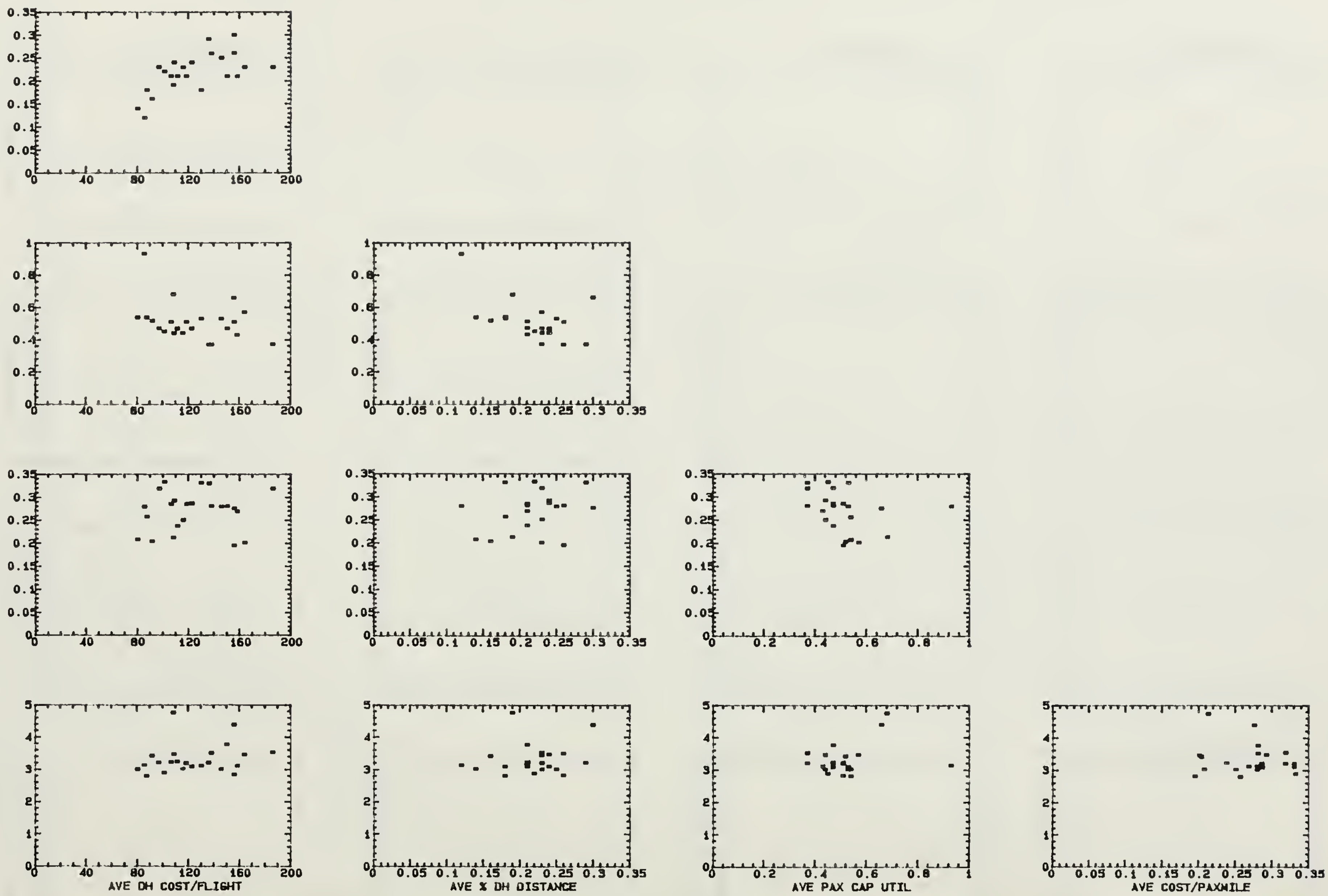

Figure F.3 - Original Draftsman's Plot - Part C

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